SPAWAR
Systems Center
San Diego

TECHNICAL DOCUMENT 3028
April 1998

Advanced Refractive Effects Prediction System (AREPS)

Version 1.0 User's Manual

Wayne L. Patterson

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San Diego, California 92152–5001

H. A. Williams, CAPT, USN
Commanding Officer

R. C. Kolb
Executive Director

ADMINISTRATIVE INFORMATION

The Advanced Refractive Effects Prediction System (AREPS): Version 1.0 User's Manual was funded by the Space and Naval Warfare Systems Command, PMW 185. Wayne L. Patterson of the Tropospheric Branch, Space and Naval Warfare Systems Center, D883, prepared the manual under program element 0603207N, accession number DN305062, work unit D88–MP67.

Note: the AREPS program software supplied with this document has the same classification and distribution as the document.

Released by
R. A. Paulus, Head
Tropospheric Branch

Under authority of
J. H. Richter, Head
Propagation Division

LH

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GETTING STARTED

About AREPS

The Advanced Refractive Effects Prediction System (AREPS) program computes and displays a number of tactical decision aids. These are radar probability of detection, electronic surveillance measure (ESM) vulnerability, UHF/VHF communications, and simultaneous radar detection and ESM vulnerability. All decision aids are displayed as a function of height, range, and bearing. Detection probability, ESM vulnerability, and communications assessments are based on electromagnetic (EM) system parameters stored in a changeable database you maintain. Paths containing land features depend on terrain data either obtained from the National Imagery and Mapping Agency's (NIMA) Digital Terrain Elevation Data (DTED) or specified from your own source.

All calculations depend on atmospheric refractivity data derived from radiosondes or other sensors. The propagation model used is the Advanced Propagation Model (APM). AREPS creates a height versus range coverage diagram for each azimuth desired. Each coverage diagram is stored in a bitmap graphics file. When all coverage diagrams requested have been computed and stored, AREPS displays the coverage diagrams in rapid sequence, rotating through the various azimuths. You may change the rotation speed, pause the sequence at any azimuth, step the sequence forward in azimuth one diagram at a time, or step the sequence backward in azimuth one diagram at a time. For each diagram, you may also display a propagation loss versus range and/or height decision aid. Using a mouse or other pointing device, you may display many additional pieces of information, including height, range, latitude, and longitude from the decision aid's geographical center, terrain elevations, and propagation loss values.

Installing/Uninstalling AREPS

Hardware and Operating System Requirements

You may install and run AREPS on an IBM PC or 100 percent compatible computer running the U.S. English regional version of the Microsoft Windows® operating system. The minimum hardware requirement to run AREPS is the same as the minimum requirements for the operating system. A CD-ROM drive is highly recommended. To take advantage of the full capabilities of the AREPS program, we recommend a Pentium class computer, at least 16 megabytes of random access memory (RAM), a large hard disk drive (1 gigabyte or larger), and a printer. While the AREPS program has been tested in all screen modes for large and small fonts, it is designed for an 800x600 (or larger) small font display. Should the AREPS windows fail to appear in proper proportion or scroll bars appear on all AREPS windows, we recommend setting the computer's display to the 800x600 (or larger) small font mode if your monitor will allow it.

The AREPS program runs under the U.S. English regional setting of Windows 95, 98, NT 3.51 and NT 4.0. If your regional setting is something other than U.S. English, AREPS may not function correctly. Some regional settings substitute the comma character for the decimal point character. This will cause type mismatch errors while working with the EM system database. If this occurs and you still desire to use AREPS, you must change your regional setting to U.S. English. This change is made from the regional settings icon found in the Windows Control Panel.

Regional Settings

Installing AREPS

AREPS normal distribution is via the Internet or on a CD-ROM. Contact technical support about other distribution options. If you are installing AREPS and a previous version currently exists on your computer, we recommend you uninstall and remove it prior to installing it again.

If you are installing AREPS under Windows NT, you must have system administrator authority.

▶ **To obtain and install AREPS from the Internet.**

Steps	Comments
1	Request the AREPS software from our Internet homepage (http://sunspot.spawar.navy.mil) by clicking on the **Request AREPS** hypertext link.
2	Complete the AREPS registration form. If you request, we will use your email address to inform you of any software service packages or other items of general interest. Your information will not be used for any other purpose. When the registration form is complete, click on the **Send request to SSC** button.
3	AREPS is segmented into parts, each of which is sized to fit on a 3.5-inch floppy diskette. Click on the hypertext link for each segment and save it in a temporary folder.
4	After all the segments have been obtained, move to the temporary folder and double click on the first segment's file name (*areps1.exe*). It will automatically expand its contents. The default expansion folder is your system's temporary folder, but you must choose the temporary folder containing the other segment files.

Steps	Comments
5	Double click *Setup.exe* and follow any instructions provided on the screen. After AREPS is installed, you may delete all the compressed and expanded segment files. Prior to deleting the compressed segment files, you may wish to copy them onto floppy diskettes for installation on another computer.

▶ **To install AREPS from a CD-ROM.**

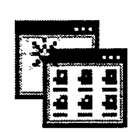
Steps	Comments
1	Insert the CD-ROM distribution disk into your CD drive.
2	Click the **Start** button, point to **Settings**, and then click the **Control Panel** icon.
3	Double click the **Add/Remove Programs** icon.
4	Follow the instructions on your screen.

▶ **To create AREPS program shortcut.**

To get to the AREPS program more quickly once it is installed, you may wish to create a shortcut icon on your desktop.

Steps	Comments
1	In My Computer or Windows Explorer, locate the *AREPS.EXE* file.
2	Using the right mouse button, drag the program icon to the desktop.
3	Click **Create Shortcut(s) Here**.

Uninstalling AREPS



When AREPS installs itself, a number of files are installed to your System subfolder. These files are dependent upon which operating system you are using. Should you need to remove the AREPS program, we highly recommend you use the Add/Remove program icon found in the Windows Control Panel and let the Install Shield uninstall program remove AREPS for you.

Some system files may be needed by other programs. The Install Shield uninstall program will alert you as to which files these are and will ask for your permission to remove them. If in doubt, it is best to just leave these files in place.

▶ **To uninstall AREPS**

Steps	Comments
1	Click the **Start** button, point to **Settings**, and then click the **Control Panel** icon.
2	Double click the **Add/Remove Programs** icon.
3	Select AREPS from the installed component list.
4	Click the **Add/Remove** button.

AREPS Support Services

On-line Help

If you have a question about AREPS, first look in the printed documentation, or consult Help. Each input parameter, menu item, program option, or window has its own on-line help that defines or describes the parameter and any special considerations, cautions, and proper parameter uses. The on-line help is in two forms, quick look help and full help.

▶ **To use the quick look help feature**

Point to the item in question and press the F1 key. You do not need to click a mouse button nor does the item in question have to be the current input point. Items that are currently not available (showing as gray on the screen) will not have quick look help. To get help for these items, make them active by performing any necessary action or refer to the full help. In some cases, an item may not have quick look help at all. If so, you will see the message "No HELP topic is associated with this item." For help on these items, refer to the full help feature.

▶ **To use the full help feature**

Select **Help** and then **Contents** from the AREPS main menu bar.

Technical Support

We provide no-charge support for AREPS, including help with software-related problems or questions and training and consultation in the proper use of the AREPS products. Support is available between 7:15 a.m. and 4:45 p.m. Pacific Time, Monday through Thursday, excluding holidays. Our working hours are such that every other Friday is a non-working Friday. Should you call on the non-working Friday, you may leave a message and a developer will return your call as soon as possible.

For technical support via a toll call, dial (619) 553-1424; or via the Defense Switching Network (DSN), dial 553-1424.

For technical support via the Internet, electronically mail your questions to D883@spawar.navy.mil.

For technical support via facsimile, dial (619) 553-1417.

As additional capabilities are implemented or software problems are discovered and resolved, service packs will be posted on our Internet homepage. To obtain the latest service pack, to request the complete AREPS program, to view other people's questions or ask your own, and to receive other announcements via the Internet, point your browser to our homepage at http://sunspot.spawar.navy.mil.

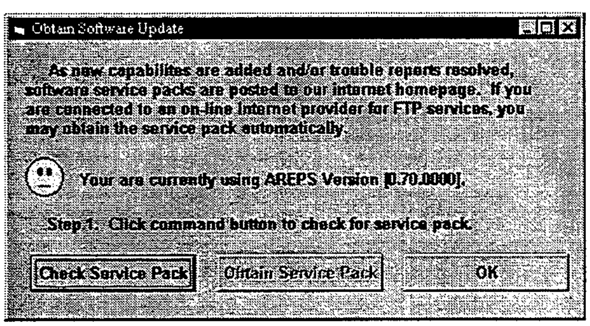


Figure 1-1: Software update window.

For those users who have an active connection to an Internet Service Provider (ISP) that supports File Transfer Protocol (FTP), AREPS provides an automatic software update feature. The software update window, shown in figure 1-1, displays the version of AREPS you are currently using. By clicking the **Check Service Pack** command button, AREPS will query our technical support Internet homepage for the most current AREPS version. If your version is not the most recent, you may click the **Obtain Service Pack** command button and the latest AREPS service pack will download to your AREPS folder. To install the service pack, follow the instructions shown in this window and those within the "Read Me" file in the service pack.

How to Run the AREPS Program

Steps	Comments
1	Start AREPS by double clicking the AREPS icon or by clicking the Windows **Start** button, clicking the **Run** button, and typing the *AREPS.EXE* file name in the run field.
2	If running AREPS for the first time, complete the program initialization information.
3	If running AREPS for the first time, populate your EM system database. Additional EM systems may be entered into the database at any time.
4	Enter the atmosphere's current refractive conditions or create an environmental file from climatology.
5	Create a new project or select a previously created project. Edit the project as necessary.
6	Click the **Execute** command button.

Navigating the AREPS Windows

The AREPS main window has controls, a menu system across the top of the window as shown in figure 1-2 and a status bar across the bottom of the window as shown in figure 1-3.

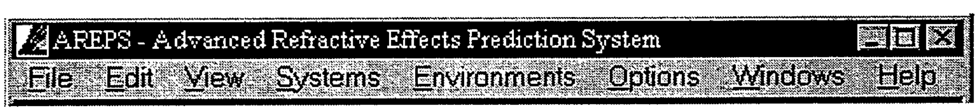


Figure 1-2: AREPS main menu.

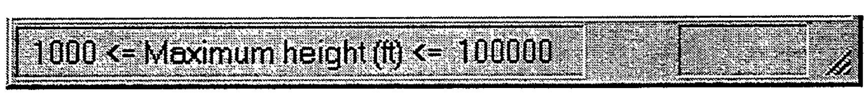


Figure 1-3: AREPS status bar.

The main menu controls all the AREPS functionality such as creating decision aids, editing data input, viewing toolbars, performing EM system database management functions, creating and displaying environmental data, setting program options, arranging all other AREPS windows, and obtaining help. All windows are opened, closed, and otherwise managed from the menu. Refer to chapter 4 (AREPS Menus) for a complete discussion of each menu item.

The status bar is divided into three panels. The left panel provides limit information about the AREPS control that currently requires your attention (has the focus). The right panel provides information about how to select an item or how to obtain an optional menu. The center panel shows the status of certain keys such as the NUM LOCK key.

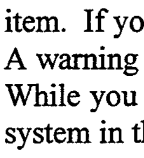
All other AREPS windows contain a combination of data input points (controls) which gain focus when they are accessed. You use these input points to provide any necessary data. At the top of each window is a title bar describing the window's type. Since Windows is capable of multi-tasking, more than one window of the same type may be open at the same time; for example, you may have three radar windows open simultaneously. If so, the window's number shows in the title bar as Element(0), Element(1), etc. You have access to the AREPS menu system at any time, except when the Options window and the Error window are open. These two windows require you to make a critical decision before AREPS can proceed.

Entering or Editing Data

A flashing cursor for text fields or a highlighted background for other controls shows the item which has the focus. An instructional prompt for this item shows in the status bar. For a text field, when the field first gains your attention, the text will be highlighted. While highlighted, the DELETE key will erase the contents of the field. If the text is not highlighted, the DELETE key will erase only the character to the right of the cursor. To input or edit data, just type a new value. Once any change is made to a field, the highlight will disappear. The ← and → keys move the cursor to the left and right within the field. The ↑ and ↓ keys move the cursor up and down within a tabular form. It is not necessary to press the ENTER key before moving to another field.

Data Limits

AREPS assigns limits to most input items. The limits are divided into two groups, a hard limit group and a soft limit group. Hard limits may not be exceeded and will not be accepted. Soft limits are those we consider to be out of the normal usage range but we will still allow you to enter. An input item's validity range shows in the left panel of the status bar. If you exceed a hard limit, the background color of the input value will turn to red. An error message shows and your only option is to re-enter the item. If you exceed a soft limit, the background color of the input value will turn yellow. A warning message shows and you may choose to re-enter the value or accept the value. While you may leave a field with an unresolved error, you will not be allowed to save a system in the database or create a decision aid until the hard limit error is corrected.



A value outside the valid range may yield erroneous BUT NOT NECESSARILY OBVIOUSLY WRONG results and may cause AREPS to abort with a runtime error, may cause loss of computer memory, or may cause some other undesirable consequence. You are encouraged to adhere to the recommended limits when entering a value.

Changing Units

All allowable units are preprogrammed and you may not deviate from them. Units may be changed by typing the first letter of the desired unit in the input field, or by clicking the right mouse button on the information label appearing adjacent to the field. For items within a tabular form, you may click the right mouse button on the column's title bar. For a right mouse click, a unit's selection popup menu appears. Highlight your choice with the ↑ and ↓ keys and press the ENTER key, or click on your choice with the left mouse button.

When you change units, the value may or may not be converted. By default, the value is not converted. You may change the default by selecting the **Convert the input value when its units change** check box from the **Save/Edit** item on the **Options** menu. More than one field may be "tied" to a particular unit, especially for items in a tabular form. Converting such a field will convert ALL fields tied to that unit. For example, when entering pressures in the Environment window, changing any pressure from millibars to inches of Mercury will cause all pressures to be converted. For the Environment window, changing units without converting the values will cause the calculated height versus M-unit profile to become a whole new profile. By changing the units and converting the values, the profile remains the same.

When values are converted, they may be rounded with a loss in precision. Converting the value again could compound the rounding error. Therefore, changing back to the original units may not convert the value back to its original value. USE THE CONVERT UTILITY WITH CARE.

Initializing AREPS

When starting AREPS for the first time, an initialization window, figure 1-4, opens showing the proposed AREPS folder structure. The DTED Terrain folder contains terrain data for your projects. The System database folder contains your EM system database file.

Normally your database file will be in the AREPS main folder. However, you may want to have your database file reside on a removable disk so it may be kept in a secure location when AREPS is not in use.

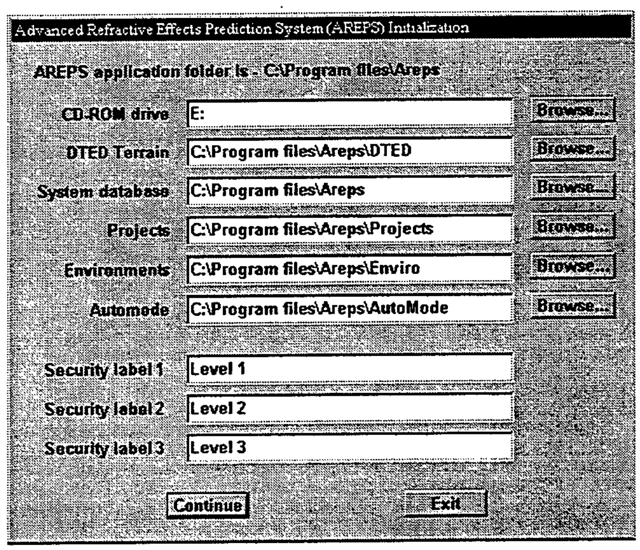


Figure 1-4: Initialization window.

The Projects folder contains a number of subfolders for the projects you create. Each project becomes a subfolder of the Projects folder and contains all the necessary files to run and display your project in addition to any optional files you request for your project.

The Environment folder contains all your environmental files and any terrain files you create. The Automode folder contains any Automode menus you create. Automode is not implemented in AREPS version 1.0. You may change the folder structure by typing new folder paths, or choose a folder name from the Change folder window opened by clicking on the **Browse** button. In addition, you may change the location of these folders on subsequent runs of the AREPS program by selecting **Files and Folders** from the **Options** menu.

In addition to the proposed folder structure, the initialization window contains three input fields for your security definitions. AREPS allows you to label your data with four different security labels. For example, label 1 may be "My eyes only." Label 0 is predefined as "None" and may not be changed. It is your sole responsibility to adhere to the data security requirements dictated by higher authorities. This utility is strictly a convenient labeling feature and, as such, the AREPS developers assume no responsibility for unauthorized release of classified data or misuse of this feature. You may change the security labels on subsequent runs of the AREPS program by selecting **Files and Folders** from the **Options** menu.

After you enter your security labels, and if the folder structure is acceptable (we recommend it), click on the **Continue** button to continue. The initialization information is stored in the program's mail folder under a binary file named *areps.ini*. You may not read or edit the file with an external text editor such as Notepad. If you delete the areps.ini file, it must be created again the next time you start AREPS. A title window, figure 1-5, providing support information now opens. At the top of the title window is the AREPS menu system. Clicking on any menu item clears the title graphic.

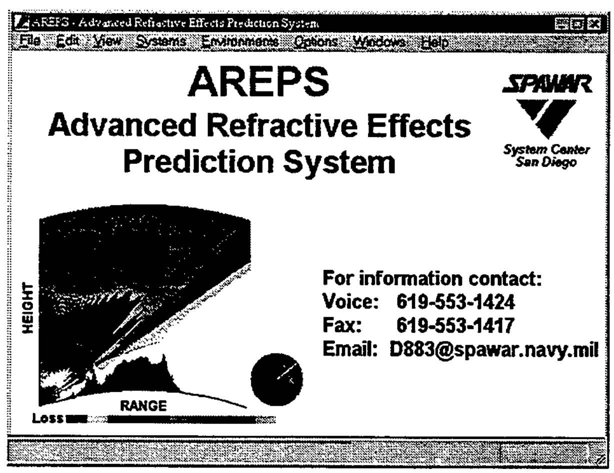


Figure 1-5: AREPS title window.

Populating Your EM System Database

If this is your first time running AREPS, you will want to populate your EM system database. There are three ways to populate the EM system database: enter each system individually from the menu system, import an EM system database created from the Radio Propagation Over Terrain (RPOT) program, or open an EM system database

provided by another agency. U.S. military organizations may contact technical support for additional information about EM system parameters.

▶ **To enter an individual EM system from the system menu.**

Follow these steps for each system you wish to enter into the database. For a detailed discussion of each EM system window, refer to chapter 5 (Project and EM Systems).

Steps	Comments
1	Select **Systems** from the AREPS menu and then **New** Radar, Target, ESM, or Communication. A specialized data input window opens for each system.
2	Enter the necessary data.
3	Click the **Save** command button. A Save System window opens allowing you to enter a name for your newly created system.
4	Should you choose to create another system with just a slight variation of data, you may edit the necessary fields and then select **Save As** item from the **File** menu. The Save/Open System window will open so you may enter a new name.
5	When you are finished, click the **Cancel** command button or click the **Close** command button located in the window's upper right corner.

▶ **To import a RPOT database.**

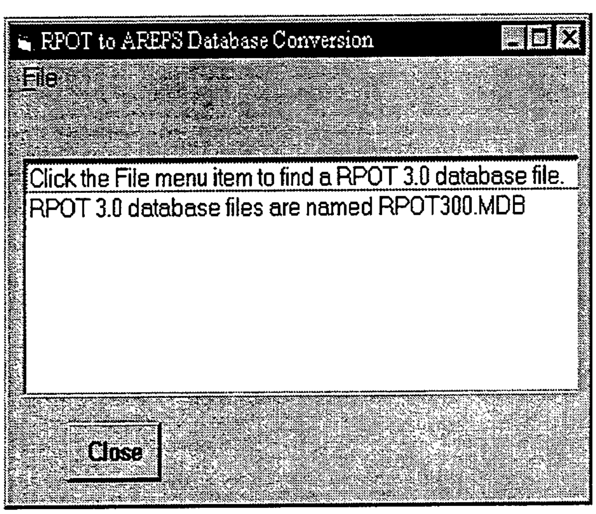


Figure 1-6: RPOT to AREPS database conversion utility.

For the convenience of those who use our RPOT program, we provide a stand-alone utility program (**RpotToAreps.exe**) that will convert a RPOT 3.0 database into an AREPS database. The RPOT database is unaffected by the conversion, so it may still be used with the RPOT program. The program is installed into the AREPS main folder.

► **To run the RpotToAreps program**

Steps	Comments
1	Start the RpotToAreps.exe program as any other Windows program.
2	Select the **Open RPOT 3.0 database** item from the **File** menu as shown in figure 1-6.
3	Using the **Open** window, locate and open the RPOT database. If you use the RPOT default installation, its name and location is *c:\Program Files\rpot\rpot300.mdb*.
4	Select the **Save as AREPS 1.0 database** item from the **File** menu. Then click the **Close** command button. By default, the database is saved in the AREPS main folder with a name of ArepsData.mdb. If you save it in a different folder, you must change the database folder by using the **Folder and Drives** items from the **Options** menu. If you save it under a different name, you must specifically open it by using the **Open database** item on the File menu.

► **To open an EM system database from another agency.**

AREPS can use only one EM system database at a time. By default, the database filename is ArepsData.mdb and it is located in the AREPS main folder.

Steps	Comments
1	Select **Files** from the AREPS menu and then **Open Database**.
2	The Explorer window will open, allowing you to enter a file name. By default, the database file name is *ArepsData.mdb* but it may be named anything by the providing agency.
3	Using the Explorer window controls, locate the desired database file and click the **Open** button.

Entering the Current Atmosphere's Condition

Prior to creating or executing a project, you need to create at least one height versus M-unit profile environment file. Select **Environments** from the AREPS menu

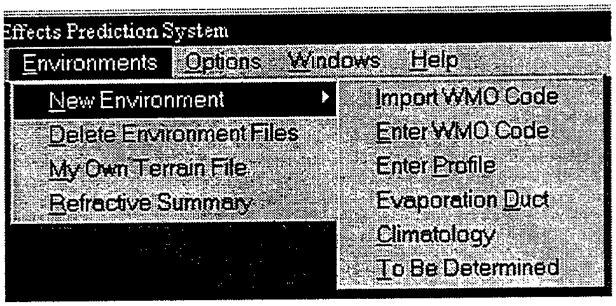


Figure 1-7: Environments menu.

and then choose one of the environmental data input methods as shown in figure 1-7. Refer to chapter 7 (The Environment) for a complete discussion on each input method.

Creating and Running a Project

Select either **New Project** or **Open Project** from the **Files** menu. A project window opens, allowing you to specify the radar, platform, target, ESM receiver, communications system, environment, location, bearing(s), and maximum range and height and axis display options. For a complete discussion of the project window, refer to chapter 5 (Project and EM System).

After the project information is entered, click the **Compute** button. This action saves the current project information and begins computations. If the project requires terrain not previously copied from DTED CD-ROMs, you are asked to insert the appropriate DTED CD-ROMs into the CD drive. You may skip the CD-ROMs should they not be available, or you may select **Terrain** from the **Options** menu to specify the name of a file containing your own terrain data. If DTED terrain files are used, they are copied to the hard drive and a full-circle or wedge terrain map is (optionally) created. AREPS creates a terrain profile for each azimuth and then executes the Advance Propagation Model (APM) program to generate the appropriate coverage diagram. After all the diagrams are created, AREPS displays the coverage diagrams in sequence. Refer to chapter 9 (Decision Aids) for a further discussion of decision aid options and displays.

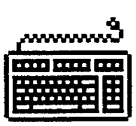
CONVENTIONS AND FILES

Terms and Conventions

Typographical Conventions

Formatting convention	Type of information
Triangular bullet (▶)	Step-by-step procedures. Complete the procedural instructions by using either the mouse or the keyboard.
Bold type	Words or characters you type or a menu item you select. For example, if the instructions are to type **run setup**, you type the lowercase letters "run" followed by a space and the lowercase letters "setup."
Italic type	Specialized terms, titles of books or manuals, or placeholders for items you must supply, such as a filename. For example, if the instructions are to type *folder name*, you type the name of the folder.

Keyboard Conventions

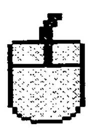


All key names are in capital letters. For example, the Control key is CTRL and the Escape key is ESC. (The keys on your keyboard may not be labeled exactly as used here.)

Keys	Comments
Shortcut keys	Keys frequently used in combinations or sequences as shortcut keys. For example, SHIFT+F1 means to hold down the SHIFT key while pressing the F1 key, and ALT, F, A means press and release each key in order.
RETURN and ENTER	These keys perform the same action in AREPS. In most cases, the ENTER key will move the focus from one data insertion point to another. It is not necessary to press the ENTER key, however, before you move to another item using the mouse.

Keys	Comments
Arrow keys (←, ↑, →, ↓), HOME, END, TAB, SHIFT TAB, PAGE UP, PAGE DOWN	Many navigation keys may be used to move the focus to a data insertion point. Some keys may be used in combinations, such as the CTRL+HOME. Some key combinations, such as the SHIFT+↑, are not available on all keyboards. In some cases, the arrow keys may cause an automatic update feature not to function correctly. If this should occur, use the mouse to select or move to an item.
Numeric keypad keys	If you have an extended keyboard, you can type numbers with the numeric keypad if you first press the NUM LOCK key.

Mouse Conventions



The most efficient method of moving about within AREPS is by using a mouse. You can use a single or multiple-button mouse with AREPS. If you have a multiple-button mouse, the left mouse button is the primary mouse button. Any procedure that requires you to click the secondary button will refer to it as the "right mouse button." Using the center button of a three-button mouse may give unpredictable results.

Term	Comments
Point	Position the mouse pointer until the tip of the pointer rests on whatever you want to point to on the screen.
Click	Press and then immediately release the mouse button without moving the mouse.
Double click	Click the mouse twice in rapid succession without moving the mouse.
Drag	Click the mouse twice in rapid secession without moving the mouse.

Data Input Point Illustrations

AREPS uses a number of different controls to accept your inputs. These are:

Controls or input point names	Illustration

Command button. A command button performs the action stated on the button. The button may have a word or just an image. Left click on the button to cause the action to happen.

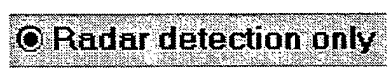
or


Check box. To check or uncheck a box, left click on the box. The ENTER key will also "toggle" the check off and on.

Dropdown menu. For some dropdown menu items, AREPS will perform automatic update functions for you. In these cases, an input field value may change. Be sure you have examined all input fields before proceeding with the program.

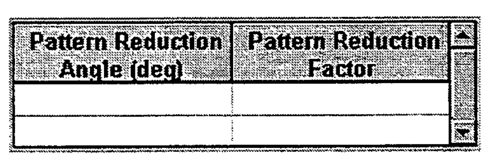
Input field. You are required to type a value into an input field. A field label and units label is generally associated with an input field. The limits of an input field show in the left panel of the status bar. To change units, right click on the field label.

Option button. Option buttons appear in a group. To select an option, left click on the option circle. The arrow keys will also move you between option buttons within the group. Selecting an option button deselects the other option buttons in the group.



Tab. The tab is a way to organize and show many options within the same window. To move between tabs, left click on the tab's label.

Tabular form. The tabular form is just rows and columns of input fields (called cells). If you are in the last cell and press the ENTER key, a new row of cells will be added to the form. The label and units show at the top of each column. To change units for all entries in the column, right click on the label.



Program Files

The distribution media of AREPS contains of a number of files that may or may not be used based upon your computer's operating system and how you choose to install AREPS. In addition to files provided on the distribution media, AREPS will create a number of files (some optional and some required) and may use files provided by other agencies. These files may be grouped into categories based upon how the files are used. So you may better understand how AREPS is structured and how AREPS will affect your disk space, the following file group discussion is provided.

Permanent Program Files

Permanent files are those that comprise the AREPS main program. These files reside in the AREPS main folder.

File name	File description
AREPS.EXE	The AREPS executable program.
AREPS.INI	Binary initialization file containing the folder structure and universal program options. You may not edit this file externally to AREPS. To change its contents, use the Options menu.
AREPS.HLP	Stand-alone Windows AREPS on-line help. You may view the help by double clicking on the file name from the Explorer window.
AREPS.CNT	On-line help table of contents
AREPSDATA.MDB	Microsoft Access Database of EM system parameters (created but not populated by AREPS if it doesn't exist.)
AREPSDATA.LDB	Microsoft Access Database index (Created by Microsoft Database manager if it doesn't exist.)
AREPS.DEP	AREPS dependency file. Used should AREPS require an update. Don't delete it.
RPOTTOAREPS.EXE	A stand-alone program that converts a RPOT database into an AREPS database.
UNINST.ISU	Install log used by Install Shield Uninstall utility. Don't delete it.

File name	File description
APMLIB.DLL	Advanced Propagation Model Dynamic Link Library. This file resides in the Windows/System folder.
RSONDE.RSD	Climatology radiosonde database.

Sample Program Files

When you install AREPS, you may also choose to install sample environment and project files. These files are located in their respective environment and project folders.

File name	File description
ELEVATED DUCT.ENV	Height versus M-unit profile for an 18,500-foot elevated ducting environment.
SURFACE DUCT.ENV	Height versus M-unit profile for a 1000-foot surface-based ducting environment.
STANDARD.ENV	Height versus M-unit profile for standard atmosphere environment.
RANGDEP.ENV	Range dependent environment with six height versus M-unit profiles. These profiles were measured from an aircraft flying a saw-tooth pattern from San Diego, CA, to Guadelupe Isle, Mexico.

Folder name	File description
3D Surface Radar Project	APM090.BMP, AREPS.INP, AREPS090.BIN, SURFACE DUCT.ENV, TERRAINMAP.BIN, TERRAINMAP.BMP, and TERRAINMAP.TXT, files necessary for the sample project. Refer to the created files discussion below for a description of each file.
AEW Aircraft Project	APM090.BMP, AREPS.INP, AREPS090.BIN, ELEVATED DUCT.ENV, TERRAINMAP.BIN, TERRAINMAP.BMP, and TERRAINMAP.TXT, files necessary for the sample project. Refer to the created files discussion below for a description of each file.

Folder name	File description
Radar and ESM Project	APM090.BMP, AREPS.INP, AREPS090.BIN, SURFACE DUCT.ENV, TERRAINMAP.BIN, TERRAINMAP.BMP, and TERRAINMAP.TXT, files necessary for the sample project. Refer to the created files discussion below for a description of each file.
UHF Communications Project	APM090.BMP, AREPS.INP, AREPS090.BIN, SURFACE DUCT.ENV, TERRAINMAP.BIN, TERRAINMAP.BMP, and TERRAINMAP.TXT, files necessary for the sample project. Refer to the created files discussion below for a description of each file.
AREPSDATA.MDB	Microsoft Access Database of EM system parameters for the systems in the sample projects.

Created Program Files

As the AREPS program executes, a number of files are created. Some of these are optional and if you choose, will automatically be removed prior to each project execution (see the **Save/Edit** tab from the **Options** menu). The first part of the file name is optional (defaults are shown). The second part of the file name is *ddd* where the *ddd* represents a bearing in whole degrees relative to true north. The file name extensions are fixed and you may not change them. AREPS will append the appropriate *ddd* and extension to all optional files even if you think you are including your own extension. For example, if you specify the name of a coverage decision aid's bitmap image as *IMAGE.001*. The created file will have the name *IMAGE.001ddd.BMP*. These created files are:

File name	File Description
AREPS.INP	ASCII text file containing the necessary file names, EM system, and display parameters required by the particular project you are executing. While you may edit this file externally to AREPS, we don't recommend it.
AREPSddd.BIN	Binary array of propagation loss values in centibels. Optional file and is saved by default.
APMddd.BMP	Bitmap image of propagation loss values. Not an optional file and is always saved. You may not change the name.

File name	File Description
AREPSddd.BMP	Bitmap image of coverage decision aid. Optional file and is not saved by default.
EREPS.EBF	Propagation loss data saved in EREPS binary format. Optional file and is not saved by default.
TERRNddd.TER	Terrain file. This file may be the one you create using the terrain window, or it may be the file created by AREPS when the DTED CD-ROM data are read. Refer to terrain file names for addition information about file name conventions.
AREPSddd.TXT	ASCII text file of propagation loss values. Optional file and is not saved by default.
TERRAINMAP.BIN	Integer array of heights. Assuming you requested a terrain map, not an optional file and is always saved. You may not change the name.
TERRAINMAP.BMP	Bitmap image of terrain map. Assuming you requested a terrain map, not an optional file and is always saved. You do have the option to recreate this image if your project's location changes. You may not change the name.
TERRAINMAP.TXT	Information used to generate TERRAIN.BMP file. Assuming you requested a terrain map, not an optional file and is always saved. You may not change the name.

Technical Support Files

Under a technical support option exercised by the support personnel, AREPS creates a number of investigation files. Unless you receive specific technical support for AREPS, you will not have these files. These files reside in the AREPS main folder.

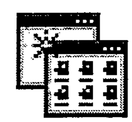
File name	File description
APMDUMP.DMP	ASCII listing of all variables in APMLIB.DLL
AREPSDEBUG.LOG	Listing of AREPS activities
ARDUMP.DMP	ASCII listing of EM system database
ANYDBASE.DAT	ASCII listing of any general database

Installation Files

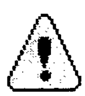
The Install Shield installation utility requires a number of instructional files. While these files exist on the distribution media, they are not part of the AREPS program and will not be copied into your computer's system folder.

	File name	
_INST32I.EXE	_ISDEL.EXE	_SETUP.DLL
_SYS1.CAB	_USER1.CAB	DAO2535.TBL
DATA.TAG	DATA1.CAB	LANG.DAT
LAYOUT.BIN	OS.DAT	SETUP.BMP
SETUP.EXE	SETUP.INI	SETUP.INS
SETUP.LID	STDOLE2.TBL	

Third-Party and Windows Support Files



When AREPS installs itself, a number of files are installed to your System subfolder. These files are dependent upon which operating system you are using. Should you need to remove the AREPS program, we highly recommend you use the Add/Remove program icon found in the Control Panel and let the Install Shield uninstall program remove AREPS for you.



Some system files may be needed by other programs. The Install Shield uninstall program will alert you as to which files these are and will ask for your permission to remove them. If in doubt, it is best to just leave these files in place. The following is a complete list of support files provided in the AREPS package.

File name	File description
ASYCFILT.DLL	Microsoft Object Linking and Embedding Library 2.20 for Windows NT and Windows 95 Operating Systems - version 2.20.4118
AXDIST.EXE	Microsoft Win32 Cabinet Self-Extractor - version 4.71.0030.1
COMCAT.DLL	Microsoft Component Category Manager Library - version 4.71
COMCTL32.OCX	Windows Common Controls ActiveX Control DLL - version 5.01.4319
COMDLG32.OCX	Microsoft Common Dialog ActiveX Control DLL - version 5.01.4319
CTL3D32.DLL	Microsoft 3D Windows Controls - version 2.31.000

File name	File description
DAO350.DLL	Microsoft Data Access Object Library - version 3.50.3602.0
DFORRT.DLL	DEC Fortran Support file
INETWH16.DLL	Adds Internet access to help using HC31/HCP help compiler.
INETWH32.DLL	Adds Internet access to help using HCW help compiler.
MSEXCL35.DLL	Microsoft Jet Excel ISAM - version 3.50.3602.5
MSINET.OCX	Microsoft Internet Transfer Control - version 5.01.4511
MSJET35.DLL	Microsoft Jet Engine Library - version 3.51.0623.4
MSJINT35.DLL	Microsoft Jet Database Engine International - version 3.50.3602.5
MSJTER35.DLL	Microsoft Jet Database Engine Error Library - version 3.50.3602.0
MSLTUS35.DLL	Microsoft Jet Lotus 1-2-3 Isam - version 3.50.3602.5
MSPDOX35.DLL	Microsoft Jet Paradox ISAM - version 3.50.3602.0
MSRD2x35.DLL	Microsoft RED ISAM - version 3.50.3602.0
MSREPL35.DLL	Microsoft Replication Library - version 3.51.0623.0
MSTEXT35.DLL	Microsoft Jet Text Isam - version 3.50.3602.0
MSVBVM50.DLL	Visual Basic Virtual Machine - version 05.00.4319 (SP2)
MSVCRT.DLL	Microsoft C Runtime Library - version 5.00.7022
MSVCRT40.DLL	Microsoft C Runtime Library - version 4.10.6038
MSXBSE35.DLL	Microsoft Jet xBase Isam - version 3.50.3602.0
OLEAUT32.DLL	Microsoft OLE 2.20 for Windows NT(TM) and Windows 95(TM) Operating Systems - version 2.20.4118
OLEPRO32.DLL	Microsoft (R) OLE Property Support - version 5.0.4118
SETBROWSE.EXE	Utility program to specify an Internet browser.

File name	File description
SS32x25.OCX	FarPoint Technologies, Inc. Spreadsheet Control - version 2.5.020
TABCTL32.OCX	Microsoft Tabbed Dialog OLE Control - version 5.01.4319
VBAJET32.DLL	Microsoft Visual Basic Application Development Environment Expression Service Loader - version 5.0.7122
VBAR332.DLL	Visual Basic for Applications Runtime Expression Service - version 3.0.6908
WINT351.EXE	Win32 Cabinet Self-Extractor for NT 3.51 - version 4.71.0030.1

THE EARTH'S ATMOSPHERE

Structure and Characteristics

The earth's atmosphere is a collection of many gases together with suspended particles of liquids and solids. Excluding variable components such as water vapor, ozone, sulfur dioxide, and dust, the gases of nitrogen and oxygen occupy about 99 percent of the volume, with argon and carbon dioxide being the next two most abundant gases. From the earth's surface to an altitude of approximately 80 kilometers, mechanical mixing of the atmosphere by heat-driven air currents evenly distributes the components of the atmosphere. At about 80 kilometers, the mixing decreases to the point where the gases tend to stratify in accordance with their weights.

The lower, well-mixed portion of the atmosphere is called the homosphere, while the higher, stratified portion is called the heterosphere. The bottom portion of the homosphere is called the troposphere.

The troposphere extends from the earth's surface to an altitude of 8 to 10 kilometers at polar latitudes, 10 to 12 kilometers at middle latitudes, and up to 18 kilometers at the equator. It is characterized by a temperature decrease with height. The point at which the temperature ceases to decrease with height is known as the tropopause. The average vertical temperature gradient of the troposphere varies between 6 and 7 degrees Celsius per kilometer.

The concentrations of gas components of the troposphere vary little with height, except for water vapor. The water vapor content of the troposphere comes from evaporation of water from oceans, lakes, rivers, and other water reservoirs. Differential heating of land and ocean surfaces produces vertical and horizontal wind circulations that distribute the water vapor throughout the troposphere. The water vapor content of the troposphere rapidly decreases with height. At an altitude of 1.5 kilometers, the water vapor content is approximately half of the surface content. At the tropopause, the content is only a few thousandths of what it is at the surface.

In 1925, the International Commission for Aeronavigation defined the international standard atmosphere. This is a hypothetical atmosphere having an arbitrarily selected set of pressure and temperature characteristics that reflect an average condition of the real atmosphere.

Refraction

Index of Refraction

The term refraction refers to the property of a medium to bend an electromagnetic wave as it passes through the medium. A measure of the amount of refraction is the index of refraction, n, defined as the velocity, c, of propagation in free space (away from the influence of the earth or other objects) to the velocity, v, in the medium. This is

$$n = \frac{c}{v} . \quad (1)$$

Refractivity and Modified Refractivity

The normal value of the refractive index, n, for the atmosphere near the earth's surface varies between 1.000250 and 1.000400. For studies of propagation, the index of refraction is not a very convenient number, therefore a scaled index of refraction, N, called refractivity, has been defined. At microwave frequencies and below, the relationship between the index of refraction n and refractivity N for air that contains water vapor is given as

$$N = (n-1)10^6 = \frac{77.6\,p}{T} + \frac{e_s\,3.73 \cdot 10^5}{T^2} , \quad (2)$$

where e_s is the partial pressure of water vapor in millibars or

$$e_s = \frac{rh\ 6.105\ e^x}{100} , \quad (3)$$

$$x = 25.22 \frac{T - 273.2}{T} - 5.31 \log_e \left(\frac{T}{273.2} \right) , \quad (4)$$

$p =$ atmosphere's barometric pressure in millibars,
$T =$ atmosphere's absolute temperature in Kelvin, and
$rh =$ atmosphere's relative humidity in percent.

Thus, the atmospheric refractivity near the earth's surface would normally vary between 250 and 400 N-units.

Since the barometric pressure and water vapor content of the atmosphere decrease rapidly with height while the temperature decreases slowly with height, the index of refraction, and therefore refractivity, normally decreases with increasing altitude.

As a tool in examining refractive gradients and their effect upon propagation, a modified refractivity, defined as

$$M = N + 0.157\,h \quad \text{for altitude } h \text{ in meters and} \quad (5)$$

$$M = N + 0.048\,h \quad \text{for altitude } h \text{ in feet,} \quad (6)$$

is often used in place of the refractivity.

Effective Earth Radius

In free space, an EM wave will travel in a straight line because the index of refraction is the same everywhere. Within the earth's atmosphere, however, the velocity of the wave is less than that of free space, and the index of refraction normally decreases with increasing altitude. Therefore, the propagating wave will be bent downward from a straight line. It is convenient to compute refractive effects in terms of waves traveling in straight lines. Replacing the actual earth's radius with an effective earth radius and replacing the actual atmosphere may approximate this by one that is homogeneous in nature.

The effective earth radius factor, k, is defined as

$$k = \frac{1}{\left(1 + 10^{-6}\, a\, \dfrac{\mathrm{d}N}{\mathrm{d}z}\right)} = \frac{1}{\left(10^{-6}\, a\, \dfrac{\mathrm{d}M}{\mathrm{d}z}\right)}, \qquad (7)$$

where $\frac{\mathrm{d}N}{\mathrm{d}z}$ and $\frac{\mathrm{d}M}{\mathrm{d}z}$ are the N and M gradients, respectively, and z is in the same units as a. The mean earth radius is generally taken to be $6.371 \cdot 10^{6}$ meters. For standard refractive conditions where $\frac{\mathrm{d}N}{\mathrm{d}z} = -0.039$ N-units per meter or $\frac{\mathrm{d}M}{\mathrm{d}z} = 0.118$ M-units per meter, $k = 1.33$ or four-thirds.

Refractive Conditions

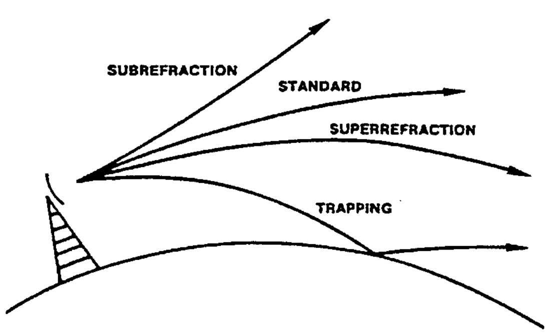


Figure 3-1: Refractive conditions.

Figure 3-1 illustrates the four refractive conditions as discussed below.

Standard and Normal Conditions

The refractivity distribution within the atmosphere is nearly an exponential function of height. The exponential decrease of N with height close to the earth's surface (within 1 kilometer) is sufficiently regular, however, to allow an approximation of the exponential function by a linear function. This linear function is known as a *standard* gradient and is characterized by a decrease of 39 N-units per kilometer or an increase of 118 M-units per kilometer. A standard

gradient will cause traveling EM waves to bend downward from a straight line. Gradients that cause effects similar to a standard gradient but vary between 0 and -79 *N*-units per kilometer or between 79 and 157 *M*-units per kilometer are known as *normal* gradients.

Subrefractive Conditions

If the motions of the atmosphere produce a situation where the temperature and humidity distribution create an increasing value of N with height, the wave path would actually bend upward and the energy would travel away from the earth. This is termed *subrefraction.* Although this situation occurs infrequently in nature, it still must be considered when assessing electromagnetic systems' performance.

Superrefractive Conditions

If the troposphere's temperature increases with height (temperature inversion) and/or the water vapor content decreases rapidly with height, the refractivity gradient will decrease from the standard. The propagating wave will be bent downward from a straight line more than normal. As the refractivity gradient continues to decrease, the radius of curvature for the wave path will approach the radius of curvature for the earth. The refractivity gradient for which the two radii of curvature are equal is referred to as the critical gradient. At the critical gradient, the wave will propagate at a fixed height above the ground and will travel parallel to the earth's surface. Refraction between the normal and critical gradients is known as *superrefraction.*

Trapping Conditions

Should the refractivity gradient decrease beyond the critical gradient, the radius of curvature for the wave will become smaller than the earth's curvature. The wave will either strike the earth and undergo surface reflection, or enter a region of standard refraction and be refracted back upward, only to reenter the area of refractivity gradient that causes downward refraction. This refractive condition is called trapping because the wave is confined to a narrow region of the troposphere. The common term for this confinement region is a tropospheric duct or a tropospheric waveguide. It should be noted that a tropospheric waveguide is not a waveguide in the true sense of the word because there are no rigid walls that prevent the escape of energy from the guide.

The refractivity gradients and their associated refractive conditions are summarized in table 3-1.

Table 3-1: Refractive gradients and conditions.

Condition	*N*-Gradient	*M*-Gradient
Trapping	< -157 *N*/km or < 48 *N*/kft	< 0 *M*/km or < 0 *M*/kft
Superrefraction	-157 to - 79 *N*/km or -48 to -24 *N*/kft	0 to 79 *M*/km or 0 to 24 *M*/kft
Normal	-79 to 0 *N*/km or –24 to 0 *N*/kft	79 to 157 *M*/km or 24 to 48 *M*/kft
Standard	-39 *N*/km	118 *M*/km
Subrefraction	> 0 *N*/km or > 0 *N*/kft	> 157 *M*/km or > 48 *M*/kft

Atmospheric Ducts

A duct is a channel in which electromagnetic energy can propagate over great ranges. To propagate energy within a duct, the angle the electromagnetic system's energy makes with the duct must be small, usually less than 1 degree. Thicker ducts in general can support trapping for lower frequencies. The vertical distribution of refractivity for a given situation must be considered as well as the geometrical relationship of transmitter and receiver to the duct in order to assess the duct's effect at any particular frequency.

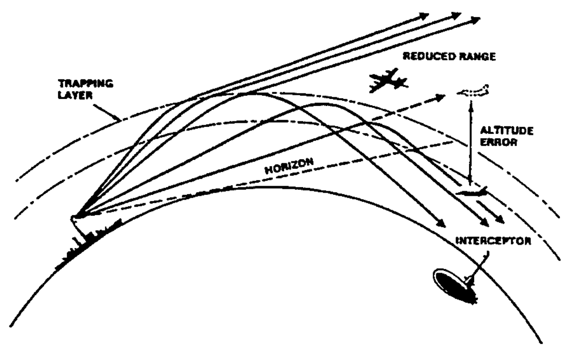


Figure 3-2: Ducting consequences.

Ducts not only give extended radar detection or ESM intercept ranges for systems within the duct, they may also have a dramatic effect upon transmitter/receiver systems that transcend duct boundaries. For example, an air target that would normally be detected may be missed if the radar is within or just above the duct and the target is just above the duct. This area of reduced coverage is known as a radar hole or shadow zone. These ducting consequences are illustrated in figure 3-2.

Although the duct acts like a waveguide for the energy, this waveguide does not have rigid and impenetrable boundaries, except for the earth's surface in cases where the duct's bottom lies at the surface. Therefore, energy is continually leaking from the duct. While the energy level within a radar hole may be insufficient for radar detection, it may be sufficient for ESM intercept of the radar.

In a discussion of ducting conditions upon EM wave propagation, the usual concern is propagation beyond the normal horizon. Within the horizon, however, ducting also has an effect. Ducting can alter the normal lobe pattern caused by the interference of the direct ray and the surface-reflected ray. The relative phase between the direct and reflected path may be changed as well as the relative amplitudes of the two rays. The effect of the duct on the line-of-sight propagation is to reduce the angle of the lowest lobe, bringing it closer to the surface.

Several meteorological conditions will lead to the creation of ducts. Where these conditions exist and what these conditions are will determine the name and nature of the duct.

Surface Ducts

If the meteorological conditions cause a trapping layer to occur, such that the base of the resultant duct is at the earth's surface, a surface duct is formed. There are three types of surface ducts based on the trapping layer's relationship to the earth's surface. The first type is a surface duct created from a surface-based trapping layer. This duct is referred to as a *surface* duct and is illustrated in figure 3-3. The second type of surface duct is created from an elevated trapping layer. This duct is commonly referred to as a *surface-based* duct and is illustrated in figure 3-4. The third type of surface duct is one created by a rapid decrease of relative humidity immediately adjacent to the air-sea interface. This duct is referred to as an *evaporation* duct. Because the evaporation duct is of great importance for over-water EM propagation, it warrants a detailed discussion. This discussion appears in its own section below.

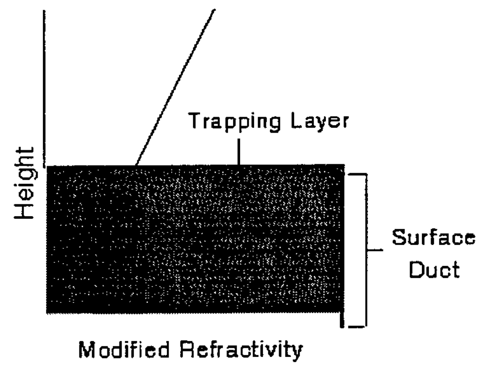


Figure 3-3: Surface duct.

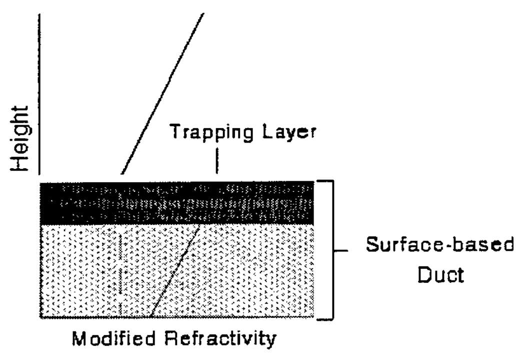


Figure 3-4: Surface-based duct.

Surface-based ducts occur when the air aloft is exceptionally warm and dry compared with the air at the earth's surface. Several meteorological conditions may lead to the formation of surface-based ducts.

Over the ocean and near land masses, warm, dry continental air may be advected over the cooler water surface. Examples of this type of advection are the Santa Ana of southern California, the Sirocco of the southern Mediterranean, and the Shamal of the Persian Gulf. This advection will lead to a temperature inversion at the surface. In addition, moisture is added to the air by evaporation, producing a moisture gradient to strengthen the trapping gradient. This type of meteorological condition routinely leads to a surface duct created by a surface-based trapping condition. However, as you travel from the coastal environment into the open ocean, this trapping layer may well rise from the surface, thereby creating the surface-based duct. Surface-based ducts tend to be on the leeward side of land masses and may occur both during the day or at night. In addition, surface-based ducts may extend over the ocean for several hundred kilometers and may be very persistent (lasting for days).

Another method of producing surface-based ducting conditions is by divergence (spreading out) of relatively cool air under a thunderstorm. While this method may not

be as frequent as the other methods, it may still enhance surface propagation during the thunderstorm activity, usually on the order of a few hours.

With the exception of thunderstorm conditions, surface-based ducting is associated with fair weather, with increased occurrence of surface-based ducts during the warmer months and in more equatorial latitudes. Any time the troposphere is well-mixed, such as with frontal activity or with high wind conditions, surface-based ducting is decreased.

An interesting feature of surface-based ducts is the skip zone near the normal horizon, in which the duct has no influence. This skip zone is easily illustrated using AREPS (see chapter 10, hardware maintenance tactical application for an illustration) or a raytrace program such as RAYS within the EREPS suite of software programs. It should be noted that the surface duct created from a surface-based trapping layer does not have this skip zone phenomenon.

Evaporation Ducts

As can be seen from the equation for refractivity, a change in the moisture distribution without an accompanying temperature change can also lead to a trapping refractivity gradient. The air in contact with the ocean's surface is saturated with water vapor. A few meters above the surface the air is not usually saturated, so there is a decrease of water vapor pressure from the surface to some value well above the surface. The rapid decrease of water vapor initially causes the modified refractivity, *M*, to decrease with height, but at greater heights the water vapor distribution will cause *M* to reach a minimum and, thereafter, increase with height. The height at which M reaches a minimum is called the evaporation duct height as illustrated in figure 3-5.

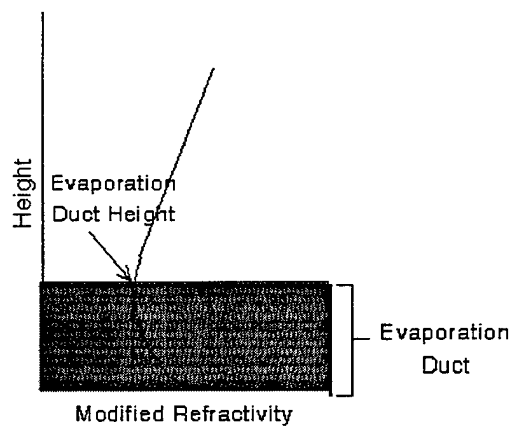


Figure 3-5: Evaporation duct.

Evaporation ducts exist over the ocean, to some degree, almost all of the time. The duct height varies from a meter or two in northern latitudes during winter nights to as much as 40 meters in equatorial latitudes during summer days. On a world average, the evaporation duct height is approximately 13 meters. It should be emphasized that the evaporation duct "height" is not a height below which an antenna must be located in order to have extended propagation but a value that relates to the duct's strength or its ability to trap radiation. The duct strength is also a function of wind velocity. For unstable atmospheric conditions, stronger winds generally result in stronger signal strengths (or less propagation loss) than do weaker winds.

Since the evaporation duct is much weaker than the surface-based duct, its ability to trap energy is highly dependent on frequency. Generally, the evaporation duct is only strong enough to affect electromagnetic systems above 3000 MHz.

Assessment of the evaporation duct is best performed by making surface meteorological measurements and inferring the duct height from the meteorological processes occurring at the air/sea interface. The evaporation duct height cannot be measured using a radiosonde, rocketsonde, or a microwave refractometer. With the advent of newer, high-resolution sondes that may be lowered to the surface from a ship, the impression is given that the evaporation duct may be measured directly. For practical applications, however, this impression is false and a direct measurement should not be attempted. Due to the turbulent nature of the troposphere at the ocean surface, a refractivity profile measured at one time would most likely not be the same as one measured at another time, even when the two measurements are seconds apart. Therefore, any measured profile would not be representative of the average evaporation ducting conditions, the conditions that an assessment system must consider.

The long-term statistical frequency distribution of worldwide evaporation ducts is readily available through our EREPS Surface Duct Summary (SDS) program or our Ducting Climatology Summary (DCS) program. Both of these programs may be obtained from our Internet homepage.

Elevated Ducts

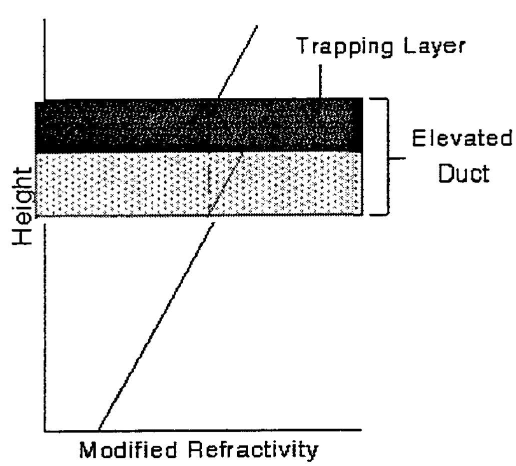


Figure 3-6: Elevated duct.

If meteorological conditions cause a trapping layer to occur aloft, such that the base of the duct occurs above the earth's surface, the duct is referred to as an elevated duct as illustrated in figure 3-6.

Great semipermanent surface high-pressure systems, centered at approximately 30 degrees north and south latitude, cover the ocean areas of the world. Poleward of these systems lay the mid-latitude westerly winds and, equatorward, the tropical easterlies or the tradewinds. Within these high-pressure systems, large-scale subsidence of air causes heating as the air undergoes compression. This leads to a layer of warm, dry air overlaying a cool, moist layer of air (often called the marine boundary layer).

The resultant inversion is referred to as the tradewind inversion and may create a strong ducting condition at the top of the marine boundary layer. Elevated ducts may vary from a few hundred meters above the surface at the eastern part of the tropical

oceans to several thousand meters at the western part. For example, along the southern California coast, elevated ducts occur an average of 40 percent of the time, with an average top elevation of 600 meters. Along the coast of Japan, elevated ducts occur an average of 10 percent of the time, with an average top elevation of 1500 meters.

It should be noted that the meteorological conditions necessary for a surface-based duct are the same as those for an elevated duct. In fact, a surface-based duct may slope upward to become an elevated duct as warm, dry continental air glides over cool, moist marine air. The tradewind inversion may also intensify, thereby turning an elevated duct into a surface-based duct.

Standard Wave Propagation

Propagation Loss and Signal-to-Noise Ratio

AREPS may present its results in terms of propagation loss or radar signal-to-noise ratio. The definitions of each term as used by AREPS is:

Propagation loss: The ratio, expressed in decibels, of the effective radiated power transmitted in the direction of maximum radiation of the antenna pattern to the power received at any point by an omnidirectional antenna. Widely used definitions of path loss are based on omnidirectional antennas. In AREPS, propagation loss is equivalent to path loss when an omnidirectional antenna is specified. Propagation loss is closely related to many definitions of transmission loss. Transmission loss generally includes effects from both an antenna pattern and the absolute gain of the antenna, whereas propagation loss only includes the pattern effects with the gain normalized to 1 (i.e., 0 dB) in the direction of maximum transmission. Therefore, propagation loss would be equal to transmission loss plus the antenna gain in decibels.

Signal-to-noise ratio: The ratio, expressed in decibels, of the signal received at the input of the radar receiver to the noise generated within the receiver itself. For AREPS, the signal level is based upon the reflection from a target of specified radar cross-section, all the engineering parameters of the radar, and the applicable propagation factors.

Standard Propagation

Standard propagation mechanisms are those mechanisms and processes that occur in the presence of a standard atmosphere. These propagation mechanisms are free-space propagation, optical interference (or surface reflection), diffraction, and tropospheric scatter.

Free-space Propagation

The simplest case of electromagnetic wave propagation is the transmission of a wave between a transmitter and a receiver in free space. Free space is defined as a region whose properties are isotropic, homogeneous, and loss-free, i.e., away from the

influences of the earth's atmosphere. In free space, the electromagnetic wave front spreads uniformly in all directions from the transmitter.

Optical Interference and Surface Reflection

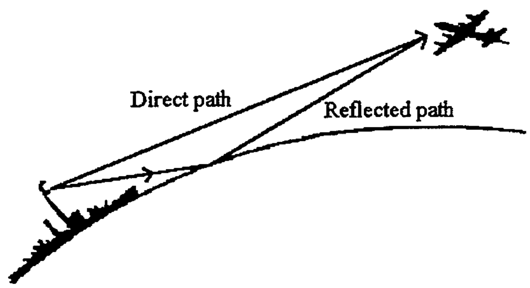


Figure 3-7: Surface reflection.

When an electromagnetic wave strikes a nearly smooth large surface, such as the ocean, a portion of the energy is reflected from the surface and continues propagating along a path that makes an angle with the surface equal to that of the incident wave as illustrated in figure 3-7.

The strength of the reflected wave is determined by the reflection coefficient, a value that depends upon the frequency and polarization of radiation, the angle of incidence, and the roughness of the reflecting surface.

For shallow incidence angles and smooth seas, typical values of the reflection coefficient are near unity (i.e., the reflected wave is almost as strong as the incidence wave). As the wind speed increases, the ocean surface grows rougher and the reflection coefficient decreases. For a transmitter near the surface, the reflection process results in two paths to a receiver within the line of sight.

As stated above, upon reflection, a portion of the energy is propagated in the direction of initial wave motion. A portion of energy is also reflected backward toward the transmitter. This backward reflected energy is also received by the radar and may interfere with the radar's ability to distinguish a desired target. This backward reflected energy is called *clutter*.

Not only is the magnitude of the reflected wave reduced, but the phase of the wave is also altered. For horizontally or vertically polarized waves at low grazing angles, the phase change upon reflection is approximately 180 degrees. Whenever two or more wave trains traveling over different paths intersect at a point in space, they are said to interfere. If two waves arrive at the same point in phase, they constructively interfere and the electric field strength is greater than either of the two component waves taken alone. If the two waves arrive together out of phase, they destructively interfere, and the resultant field strength is weakened.

As the geometry of the transmitter and receiver change, the relative lengths of the direct path and reflected path also change, which results in the direct and reflected wave arriving at the receiver in varying amounts of phase difference. The received signal strength, which is the vector sum of the signal strengths of the direct and reflected wave, may vary up to 6 dB above and 20 dB or more below the free-space value.

Diffraction

Energy tends to follow along the curved surface of an object. Diffraction is the process by which the direction of propagating radiation is changed so that it spreads into the geometric shadow region of an opaque or refractive object that lies in the radiation field. In the earth-atmosphere system, diffraction occurs where the straight-line distance between the transmitter and receiver is just tangent to the earth's surface. For a homogeneous atmosphere, this point of tangency with the earth is referred to as the geometrical horizon. For an inhomogeneous atmosphere (using an effective earth radius) and at radar and optical frequencies, this point of tangency is referred to as the radar and optical horizon, respectively.

The ability of the electromagnetic wave to propagate beyond the horizon by diffraction is highly dependent upon frequency. The lower the frequency, the more the wave is diffracted. At radar frequencies, the wavelength is small when compared to the earth's dimensions, and little energy is diffracted. At optical frequencies or very short radar wavelengths, the optical horizon represents the approximate boundary between regions of propagation and no propagation.

Tropospheric Scatter

At ranges far beyond the horizon, the propagation loss is dominated by troposcatter. Propagation in the troposcatter region is the result of scattering by small inhomogeneities within the atmosphere's refractive structure.

Anomalous Propagation Mechanisms

A deviation from the normal atmospheric refractivity leads to conditions of subrefraction, superrefraction, and trapping as explained earlier. The term anomalous propagation or nonstandard propagation applies to the above listed conditions, but it is most often used when describing those conditions that lead to radar ranges less than or greater than the normal.

Subrefractive Layers

A subrefractive layer of the troposphere would cause the propagating energy to bend upward or away from the earth's surface, thereby leading to decreased detection ranges and shortened radio horizons. Altitude errors for height-finding radars will also become evident in a subrefractive environment.

Subrefractive layers may be found at the earth's surface or aloft. In areas where the surface temperature is greater than 30 degrees Celsius, and relative humidities are less than 40 percent (i.e., large desert and steppe regions), solar heating will produce a very nearly homogeneous surface layer, often several hundreds of meters thick. Since this layer is unstable, the resultant convective processes tend to concentrate any available moisture near the top of the layer. This in turn creates a positive N gradient or subrefractive stratum aloft. This layer may retain its subrefractive nature into the early

evening hours, especially if a radiation inversion develops, trapping the water vapor between two stable layers.

For areas with surface temperatures between 10 and 30 degrees Celsius and relative humidities above 60 percent, i.e., the western Mediterranean, Red Sea, Indonesian Southwest Pacific, etc., surface-based subrefractive layers may develop during the night and early morning hours. It is characteristically caused by advection of warm, moist air over a relatively cooler and drier surface. While the N gradient is generally more intense than that described above, the layer is often not as thick. Similar conditions may also be found in regions of warm frontal activity.

Superrefractive Layers

Superrefractive conditions are largely associated with temperature and humidity variations near the earth's surface. Inversions aloft, due to large-scale subsidence will lead to superrefractive layers aloft. Superrefractive layers will lead to an increase of radar detection ranges and extensions of the radio horizon.

The effects of a superrefractive layer upon a surface-based system are directly related to its height above the earth's surface. For airborne systems, the effects of a superrefractive layer depend upon the position of the transmitter and receiver relative to the layer. Both of these factors are related to the electromagnetic wave's angle of layer penetration. The steeper the penetration angle, the less of an effect the layer will have upon propagation.

Trapping Layers

Trapping is an extension of superrefraction because the meteorological conditions for both are the same. While the usual concern is propagation beyond the normal horizon, trapping within the horizon also has an effect. Trapping can alter the normal lobe pattern caused by the interference of energy arriving at a point by the direct path and surface-reflected path. The relative phase between the direct and reflected paths may be changed as well as the amplitudes. The effect on the line-of-sight propagation is to reduce the angle of the lowest lobe, bringing it closer to the surface.

AREPS MENUS

Navigation in the AREPS program is performed with the menu system. Menus may be static and located in bars across the top of a window or may be variable and activated from right clicking on an input control or the window's background. Menu items may be represented by text or by icons. A menu item may be selected either by highlighting it with an arrow key or by left mouse clicking it.

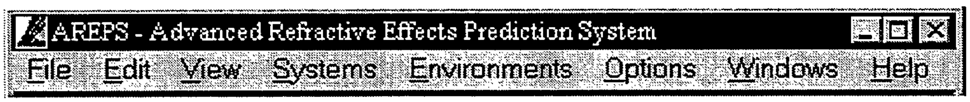


Figure 4-1: AREPS main menu.

AREPS Main Menu

The AREPS main menu, figure 4-1, is located across the top of the main window. Its items control all the AREPS functionality such as creating decision aids, editing data input, viewing toolbars, performing EM system database management functions, creating and displaying environmental data, setting program options, arranging the AREPS windows and obtaining help.

File Menu

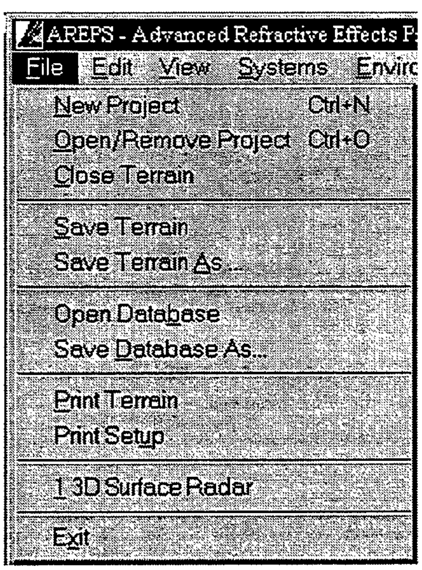


Figure 4-2: File menu.

The File menu, figure 4-2, is the starting point for an AREPS project. Projects may be created or previously created projects opened or removed with the File menu.

The File menu serves as the Close, Save, and Print point for any active window. For example, if the currently active window is a terrain window, the File menu wording will change to Close Terrain, Save Terrain, and Print Terrain. Likewise, if the currently active window is a radar window, the File menu wording will change to Close Radar, Save Radar, and Print Radar.

All of your EM system parameters are stored in the Microsoft Access database file format. The File menu allows you create and manage numerous databases for your particular application. For example, prior to the

deployment of a battle group, you may want to create a database of all the EM systems found within the battle group. You may then save this database on a floppy diskette for later use when the battle group is operating in theater.

The File menu contains a listing of up to four of the last projects you had opened. To reopen one of these projects, either highlight its name with a navigation key and press the ENTER key or just click on its name.

To close the AREPS program, select the **Exit** menu item.

Edit Menu

The Edit menu, figure 4-3, contains all the editing commands for all input fields or tabular forms. You may Cut, Delete, Copy, and Paste data with this menu. Any of these commands may also be undone with the Undo item. The menu items will be active or inactive, based upon which operation is possible. For example, the Insert terrain range and Remove terrain range menu items are active only when the tabular form in the terrain window has the focus.

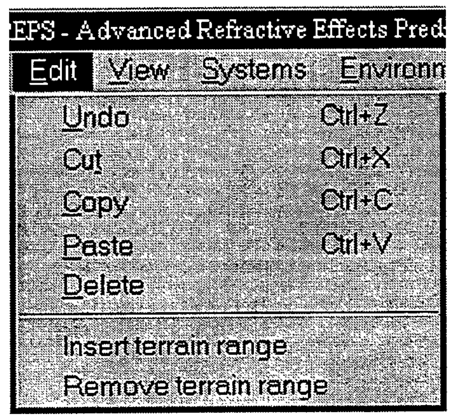


Figure 4-3: Edit menu.

View Menu

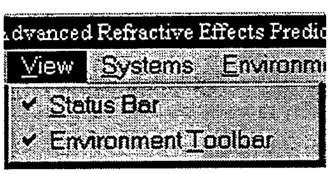


Figure 4-4: View menu.

The View menu, figure 4-4, allows you to make visible or invisible, toolbars and status bars. The check mark indicates the particular item is visible.

Systems Menu

The Systems menu, figure 4-5, allows you to perform database management functions for your Platforms, EM systems, and Targets. You may create a New item, Open an item for editing, or Remove an item from the database.

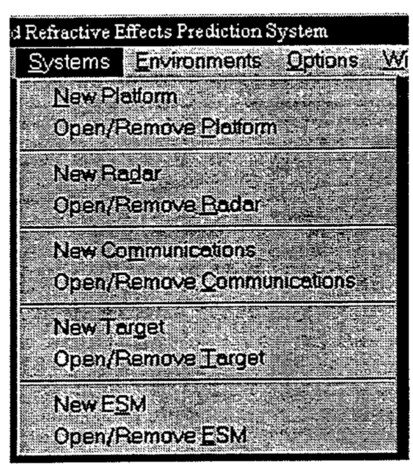


Figure 4-5: Systems menu.

Environments Menu

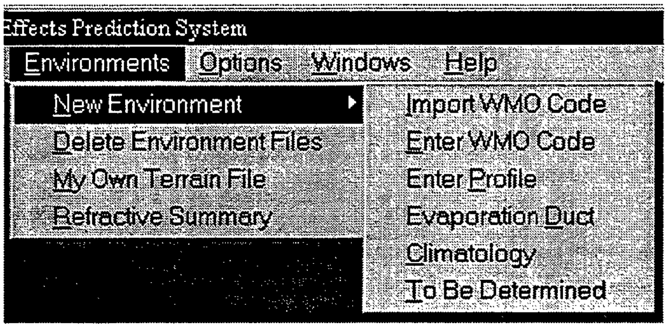


Figure 4-6: Environments menu.

The Environments menu, figure 4-6, is the entry point for creating new environmental input files, deleting environmental input files, creating your own terrain files, or displaying the contents of an environmental file using the refractive summary display. Environmental and terrain files are ASCII text files and may also be created externally to the AREPS program.

Currently, the only way to create a range and bearing dependent environmental file is to do it externally to the AREPS program. Refer to chapter 7 (The Environment) for the file conventions used in creating an environmental file externally to AREPS.

Windows Menu

Use the Windows menu, figure 4-7, to specify how you want the AREPS windows to appear on your screen. In addition to appearance options, a list of all the currently opened windows is maintained. The check mark indicates which window is currently active. If you have many windows open at the same time, you may also use the **Close All** menu item to close them all at once.

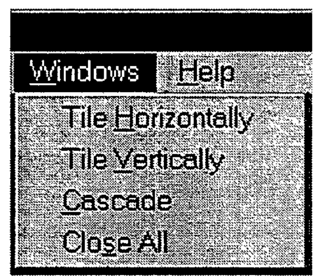


Figure 4-7: Windows menu.

Help Menu

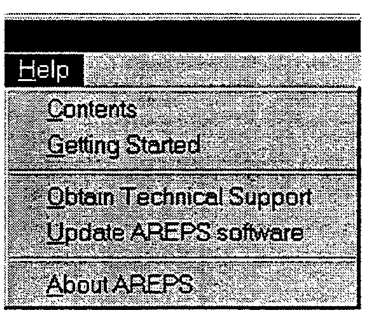


Figure 4-8: Help menu.

Use the Help menu, figure 4-8, to access the on-line help with the **Contents** item. The on-line help is also a stand-alone Windows 95/NT help file. Since it is a stand-alone file, it may also be opened and viewed by double clicking on the *areps.hlp* file from the Windows 95/NT Explorer window.

The **Getting Started** item provides information about running AREPS. The **Obtain Technical Support** item provides instructions on how to contact the AREPS support team for questions, trouble reports, and other customer service features. The **Update AREPS Software** item provides an automatic update of the AREPS software from our Internet homepage. In order to use this update feature, your computer must be actively connected

to an Internet Service Provider (ISP) that supports File Transfer Protocol (FPT). The **About AREPS** item provides information on the current version of AREPS.

AREPS Popup Menus

Change Units

You may change the units of an input field by typing the first letter of the desired unit in the input field. For example, if the input field for **Peak Power** has the focus, typing the letter "W" will change the units to watts. You may also right click on the information label appearing adjacent to the field. For example, right clicking on the **Peak Power** label brings up the Change Units popup menu as illustrated in figure 4-9.

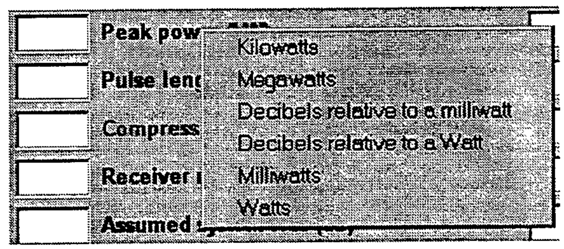


Figure 4-9: Change Units popup menu.

Should you be using the option to also convert the entered value when the units change, the Change Units popup menu will include the converted value as illustrated in figure 4-10.

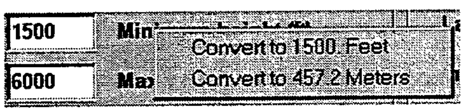


Figure 4-10: Convert Units popup menu.

PROJECT AND EM SYSTEMS

Projects are created/opened from the **Files** menu and EM systems are created/opened/removed from the **Systems** menu. When the **New** item is selected from either menu, an appropriate window opens so you may enter the necessary data. If the **Open** item is selected from either menu, an Open/Remove selection window opens.

Open/Remove Window

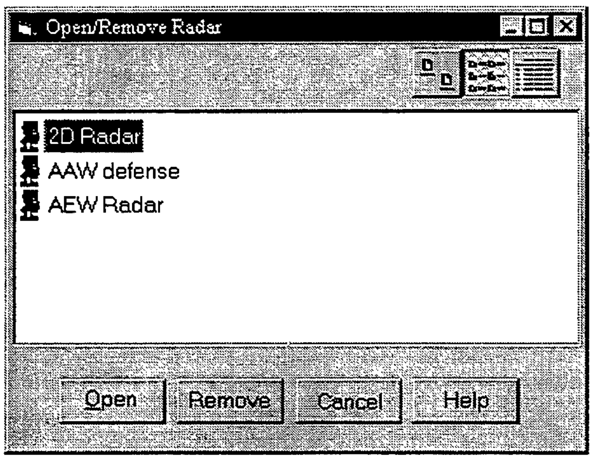


Figure 5-1: Open/Remove window.

When the **Open/Remove** (project or system type) item is selected from the Files/Systems menu, a dialog window, figure 5-1, opens offering you a choice of several command buttons. These are Open, Remove, Cancel, and Help. The title bar of the Open/Remove window will indicate what type of system you are working with.

To open an existing project or system, point to and click on a *name* from the list and then click the **Open** button or just point to and double click on the *name*. To remove a system or systems, highlight (point to and click on the first name and while holding the mouse button down, drag the mouse to the last name) those you intend to remove, and click the **Remove** button. If more than one system is highlighted, you will receive a confirmation notice. If only one system is highlighted, you will not receive a confirmation notice.

Clicking the **Cancel** button returns you to the main AREPS window where you may select another item from the AREPS menu. Clicking the **Help** button will display information about this window.

In addition to the command buttons, three views of the Open/Remove window are available. You display these views by clicking on one of the three view icons in the Open/Remove toolbar. These views are small icons as shown in figure 5-1, large icons as shown in figure 5-2, and details as shown in figure 5-3.

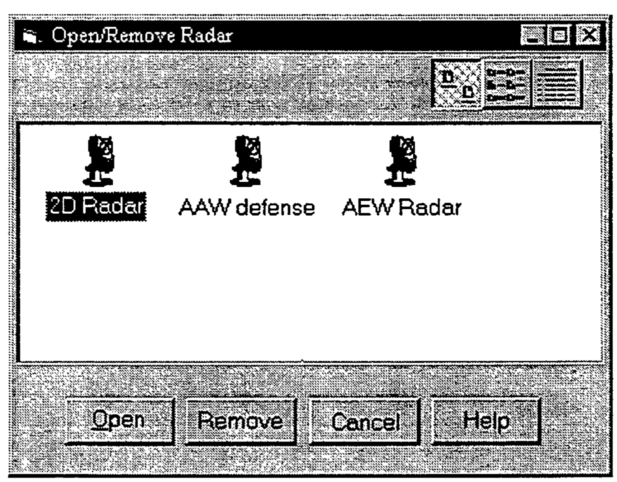


Figure 5-2: Open/Remove window – large icon view.

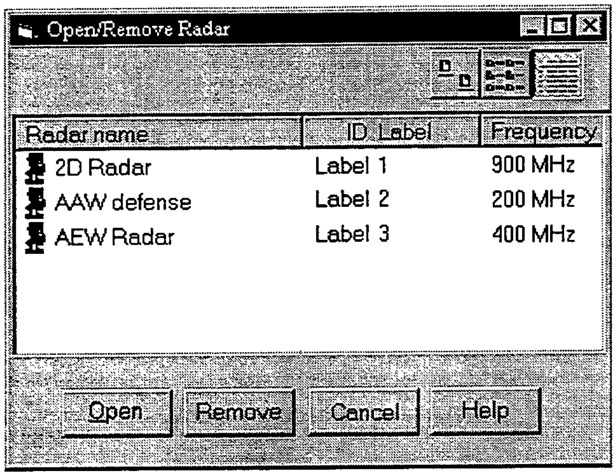


Figure 5-3: Open/Remove window – details view.

In the details view, a number of system parameters also show in the window. By clicking on the column title bar, the systems may be sorted on that particular parameter. For example, you may sort your system by name, by frequency, or (if a radar system) by identification label. Clicking on the column title a second time will sort the systems in the opposite order. For example, the first click will sort the system names in alphabetical order. The second click will sort the systems names in reverse alphabetical order.

Project Window

Each run of AREPS is considered a project. A project contains all the display, EM system, and environmental data necessary for AREPS to create your decision aid. All such input data and the resulting decision aid diagrams are saved within a subfolder of the project folder. The project window, figure 5-4, opens by selecting **New Project** or

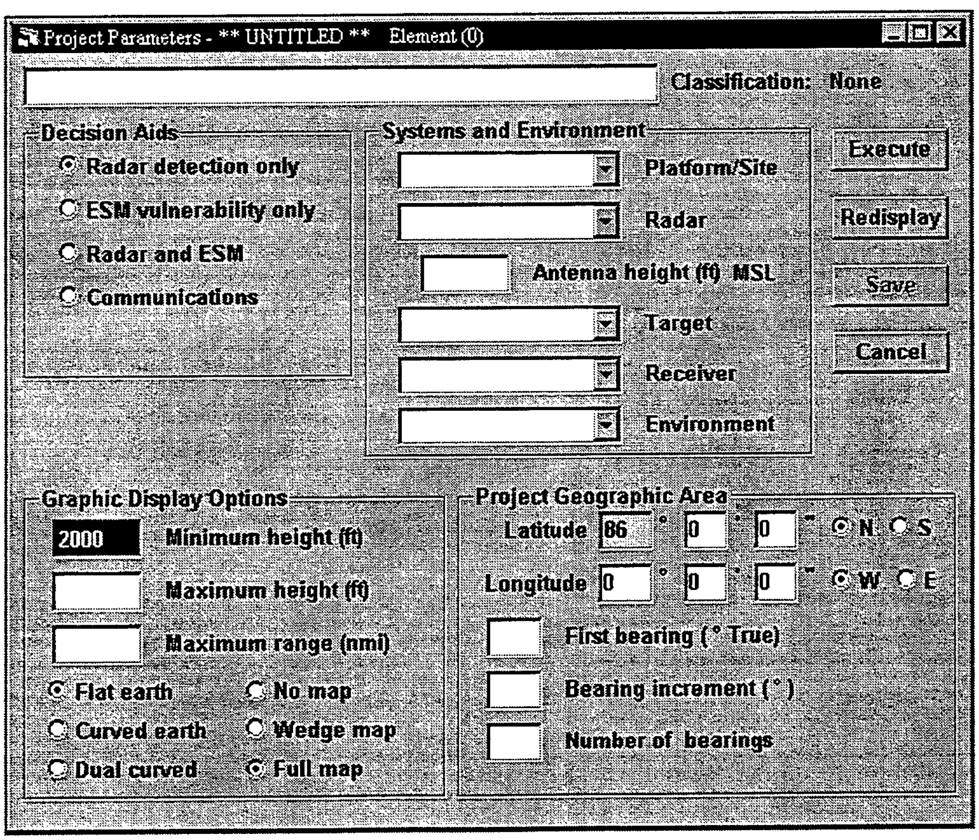


Figure 5-4: Project window.

Open/Remove Project from the File menu. Refer to navigating the AREPS window for a general discussion of data input, editing, etc. After all input data are complete, you may click the **Execute** button to start the decision aid calculations. If the project has previously been executed, you may click the **Display** button to view the project.

Figure 5-4 also illustrates an error checking convention used throughout AREPS. AREPS assigns limits to most input items. The limits are divided into two groups, a hard limit group and a soft limit group. Hard limits are limits you may not exceed and AREPS will not accept. Soft limits are those we consider to be out of the normal usage range but we will still allow you to enter. If you exceed a hard limit, the background color of the input value will turn to red (Minimum height in figure 5-4). If you exceed a soft limit, the background color of the input value will turn yellow (Latitude of figure 5-4). While you may move about a window with a limits violation, you will not be allowed to save a system or execute a project with a hard limit violation. A brief description of each input field or option item follows.

Project Label

The project label is any text you may wish to use to describe your project. This text is displayed at the top of each decision aid. You are limited to 72 characters.

Classification

AREPS allows you to label your data with four different classification labels. For example, label 1 may be "My eyes only." Label 0 is predefined as "None" and you may not change it. Label definitions are made from the **Security Labels** tab on the **Options** menu. It is your sole responsibility to adhere to the data security requirements dictated by higher authorities. This utility is strictly a labeling convenience feature and, as such, the AREPS developers assume no responsibility for unauthorized release of classified data or misuse of this feature. The project's classification is automatically determined from the highest classification of any of its system components (i.e., radar, platform, ESM receiver, etc.). The classification of your project will show on the decision aid display.

Decision Aids

Click on one of the option buttons to select a desired decision aid. The **Radar detection only** option shows radar detection probabilities or propagation loss with thresholds you select with the **Display** item from the **Options** menu. The **ESM vulnerability only** decision aid shows vulnerability and no vulnerability in two regions as two colors. The **Radar and ESM** option shows probabilities of detection and ESM vulnerability simultaneously. The **Communications** decision aid shows regions of communication and no communication.

Systems and Environment Grouping

The systems and environment is a grouping of dropdown boxes that define the project's EM system database requirements. These dropdown menus are populated from the database by clicking on the arrow to the right of the dropdown menu.

Platform/Site Name

A platform or a site is a container for an emitter such as a radar or a radio. A platform is generally thought of as a container that moves, such as a ship, aircraft, or tank. A site is generally thought of as a container that is either fixed or semi-fixed in location such as a communications bunker or a surface-to-air missile emplacement. The platforms are initialized from the **Systems** menu. The collection of emitters on the platform is called the platform's suite. When a platform is selected from the dropdown menu, the emitter names within the suite are copied into the Radar/Communications drop-down menu for your selection. For additional information about the link between the platform's emitter suite and the Radar/Communications drop-down menu, see the **Program Flow** item on **Options** menu.

Radar Name or Transmitter Name

Depending upon which decision aid you have chosen, you may select the project's radar or UHF communications transmitter from this dropdown menu. The emitter name is shown on the decision aid.

Antenna Height

The antenna height is the height of the radar or radio antenna above a reference level. The reference level may be the local ground level or mean sea level. For example, a land-based system mounted on a truck may reference its antenna height to local ground level, an ocean-based system mounted on a ship may reference its antenna height to mean sea-level, and an airborne system may reference its antenna height to either.

The height may be in either feet or meters. Antenna heights are normally entered along with the radar or communication system in the platform window. You may override any height associated with a platform, however, by clicking on the antenna height input field in the project window and entering a new height. If you do override the height specified on the platform, you are asked if you would like to have your new antenna height replace the antenna height currently in the database.

The antenna height will be added to any terrain elevation at the starting range. However, the terrain elevation may not be known until the terrain file or DTED CD-ROM is read. If the combination of heights exceeds the maximum display height, you will receive an error notice. Return to the project window and adjust the maximum display height accordingly.

Target Name

For radar decision aids, select your project's target from the Target Name dropdown menu. The target and radar you select for your project will determine the radar cross-section in square meters. The Target Name dropdown menu is gray and unavailable for the ESM vulnerability only and Communications decision aid displays. The target name is shown on the decision aid.

Receiver Name (Communications or ESM)

For ESM and communication decision aids, select the receiver's name from the Receive Name dropdown menu. Note, for communication systems, the receiver name may also be the same as the transmitter name, assuming you have a transceiver system. The receiver name is shown on the coverage diagram.

Environment Name

Choose the project's environment from the Environment Name dropdown menu. The environment created by the **Environment** menu options is stored in an ASCII text file rather than in the AREPS database. As such, its name may be any valid Windows file name up to 256 characters including spaces. To be included in the Environment Name dropdown menu, the environment file must reside in the AREPS environment folder. The environment name is shown on the coverage decision aid.

Project Geographic Area Grouping

Latitude and Longitude

The latitude and longitude (entered in degrees, minutes, and seconds) is used to extract terrain data from the DTED CD-ROMs. Click on one of the option buttons adjacent to the seconds input field to select the north, south, east, and west quadrant. The latitude and longitude specified will remain until you change it or select a stationary site. A stationary site automatically updates the latitude and longitude. If you should happen to select a mobile platform after a stationary site, the site's latitude and longitude will remain. Please insure the project's location is what you want before proceeding. If you choose to leave the latitude and longitude input field blank, the project will assume no terrain.

First Bearing

AREPS can display decision aids in a 360-degree azimuth scan. The first true bearing is that bearing for the first decision aid. The bearing may be from 0 to 360 degrees (0 and 360 are assumed to be the same bearing). It is not necessary to include leading zeros in the field. For example, 30 degrees and 030 degrees are equal.

Bearing Increment

The bearing increment is the number of whole degrees between the first bearing and the next successive bearing for an azimuth display. The minimum value is 1 degree.

Number of Bearings

This is the total number of bearings desired for an azimuth display. For example, 360 degrees of coverage will be generated if the number of bearing is 36 and the bearing increment is 10 degrees. The minimum number of bearings is 1. Care should be used in selecting the number of bearings to prevent generating more than 360 degrees of coverage. Exceeding 360 degrees of coverage will only reproduce previously generated decision aids and cause longer program execution times.

For range dependent environments, you should have the environment fully specified at each project bearing. If an environment is not specified at a project bearing, a decision needs to be made about how to proceed. You may have the decision aid use the environment at the closest bearing, use a standard atmosphere environment, or skip the decision aid for the bearing. You may make this decision before the project starts by selecting which method you would like from the **Environment** tab on the **Options** menu. You may also have the project pause and ask you for your decision when or if the event occurs.

AREPS 1.0 allows you to specify you own terrain along a single bearing. If you have requested more than one bearing and are also using your own terrain, you will receive a warning notice, the number of bearings will be automatically set to one, and the project will continue.

Graphic Display Options Grouping

Minimum Height

Use this input field to set the minimum height for the decision aid. For shipboard systems, this should be set to 0 (mean sea level). For land-based systems, a different minimum may be used. For example, the lowest elevation on earth is the Dead Sea at 1302 feet below sea level. For this geographical area, the minimum height would be set to -1302 feet. The units may be feet or meters and may be changed by right mouse clicking on the minimum height label. Units of minimum and maximum display height may not be mixed.

You must have your environment specified from this minimum height to the maximum display height. If the first height specification is above this minimum height, a decision needs to be made about how to proceed. You may have AREPS extrapolate the environment downward from the first specified height to the minimum height using either a standard atmospheric gradient or using the gradient between the first and second height levels in the specification. You may make this

decision before the project starts by selecting which method you would like from the **Environment** item on the **Options** menu.

Maximum Height

Use this input field to set the maximum height for the decision aid. The units may be feet or meters and may be changed by right mouse clicking on the minimum height label. Units of minimum and maximum display height may not be mixed.

The maximum height should be above the highest elevation of any terrain within the scope of the project. Since the terrain elevation may not be known until the project starts executing, if your maximum height is below the terrain elevation, you will receive a warning notice. Should the terrain exceed the maximum height at the first range (range zero), you must return to the project window and adjust the maximum height accordingly. Should the event occur at further ranges, a decision needs to be made about how to proceed. You may have the decision aid stop at the range where the terrain exceeds the display height, skip the decision aid for the current bearing, or you may return to the project window and change the maximum height. You may make this decision before the project starts by selecting which method you would like from the **Terrain** tab on the **Options** menu. You may also have the project pause and ask you for your decision when or if the event occurs.

Maximum Display Range

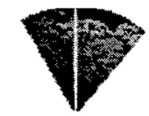
Use this input field to set the maximum range for the decision aid. For range dependent environments, you should have the environment fully specified to the display range. If it is not, a decision needs to be made about how to proceed. You may have the decision aid stop at the range of the last environment specification or you may have the last specification extrapolated to the display range. In the latter case, your environment will be horizontally homogeneous (not range dependent) from the range of the last specified profile to the display range. You may make this decision before the project starts by selecting which method you would like from the **Environment** tab on the **Options** menu. You may also have the project pause and ask you for your decision when or if the event occurs.

The units may be kilometers, nautical miles, or statute miles and may be changed by right mouse clicking on the maximum display range label. Attention should be paid to the input limits shown in the status bar's left panel as minimum ranges are different between units.

Map Options

If you desire, you may have a terrain map image placed at the lower right corner of the coverage display. As the mouse cursor moves over the map, the terrain elevation values are shown. If you specify your own terrain rather than using DTED terrain or choose not to use the DTED terrain, you may not have a terrain map display.

You may specify a **Full map,** a 360-degree terrain map centered on the selected latitude and longitude with a radius of the selected maximum display range. You may also specify a **Wedge map**, a wedge of the full map, bounded by the project bearings covered plus 5 degrees on either side, provided the terrain data are already available on the hard drive.



The **Wedge map** and **No map** options may be used to reduce the time needed to generate displays and hard disk storage requirements, since they reduce the number of needed terrain files.

Earth Surface Depiction

Radar, ESM, and communications decision aids may be displayed upon one of three different earth presentations, either a **flat**, **curved**, or **dual curved** earth as illustrated in figure 5-5.

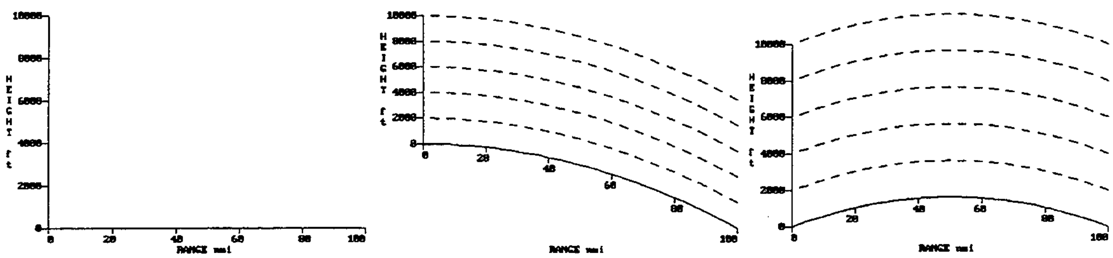


Figure 5-5: Earth surface depictions.

Use caution when selecting graphic height and range combinations with the curved earth depiction, as improperly selected values may make the display hard to interpret or misleading upon casual inspection.

Command Buttons

Execute

Click this button to start the decision aid calculations. The project will be error checked and, if error free, saved. If an error occurs, you are returned to the error point and asked to correct the problem before you may continue. After the error checking is complete you are asked for a project name if it is a new project. You may use any valid Windows folder name up to 256 characters, including spaces.

If you are using DTED terrain, the required DTED CD-ROMs will be requested, the terrain map will be created, and the terrain will be drawn. If you are using your own terrain, the terrain map will be skipped and the terrain will be drawn. AREPS 1.0 allows you to specify your own terrain along a single bearing. If you have requested more than

one bearing and are also using your own terrain, you will receive a warning notice, the number of bearings will be automatically set to one, and the project will continue.

After the terrain is drawn, the propagation model will generate the decision aid for each bearing desired. Once all decision aids are completed, they will be displayed in sequence. Using toolbar buttons, you may **Pause** the program anywhere in this process to take advantage of many additional features. You may also choose where the project pauses prior to execution from the **Program Flow** tab on the **Options** menu.

Display

Click this button to redisplay previously computed decision aids. If any project data have changed from a previous run, it is necessary for you to click the **Execute** button to ensure the coverage decision aids are appropriate to the current input data.

Save

The action of this button is the same for all AREPS windows. Click this button to save the information in the current window for later use. If you are in a new "Untitled" window, you will be asked to provide a name. For the radar, ESM, target, and communications windows, you may name the system as you wish. You are limited to 48 characters including spaces. These names are entered into the AREPS database. If this entry is a new project, the name may be any valid Windows folder name up to 256 characters, including spaces.

Should you desire to save the information in the current window under a different name for later use, select the **Save As** item from the **File** menu.

Cancel

The action of this button is the same for all AREPS windows. Click this button to ignore any changes made in the current window. The window will close.

Project Initialization File

When a project is saved, an initialization file is created. The file resides in the project's folder. The file is used to fill the data input points of the project the next time the project is opened. In addition, the project file may be electronically mailed to the AREPS support team to assist us in helping with your problems. Each line of the file is one input and the value is followed by a pound sign (#) and a comment as to what the input is. Since it is an ASCII text file, you are able to edit the file externally to AREPS, but we don't recommend it. Error checking is performed as the file is read, and any errors will be announced. The format of the file is illustrated in table 5-1.

Table 5-1: Project initialization file format.

AREPS Version [1.0.0] AREPS Project file {A}	# AREPS version number
Sample 3D Surface Radar	# Project label
0	# Classification level
0	# Display type: 0-Radar, 1-Esm, 2-Both, 3-Comm, 4-Raytrace
ddg	# Platform name
3d radar	# Radar or Comm transmitter
medium jet	# Target (Not used if Display type is 1-Esm or 3-Comm)
	# Esm or Comm receiver (Not used if Display type is 0-Radar)
Surface duct.env	# Environment filename
75	# Antenna height in m
m	# Antenna height units
118800	# Latitude in seconds = 33°00'00"N
424800	# Longitude in seconds = 118°00'00"W
0	# First bearing in degrees
10	# Increment bearing in degrees
2	# Number of bearings
0	# Minimum Height in ft
5000	# Maximum Height in ft
100	# Maximum range in nmi
ft	# Min Ht and Max Ht units
nmi	# Max Range units
2	# Type of terrain map: 0-No map, 1-Wedge only, 2-Full circle
0	# Type of plot: 0-Flat, 1-Curved, 2-Dual curved
true	# Use latitude and longitude

Platform Window

The Platform window, figure 5-6, opens by selecting New Platform or Open/Remove Platform from the Systems menu.

Platform Type and Location Grouping

A platform or a site is a container for an emitter such as a radar or a radio. A platform is generally thought of as a container that is mobile such as a ship, aircraft, or tank. A site is generally thought of as a container that is either fixed or semi-fixed in location such as a communications bunker or a surface-to-air missile emplacement.

If the platform is mobile (i.e., ship, plane, tank, etc.), check this box. The platform's latitude and longitude input fields become unavailable. If the platform is stationary (i.e., a communications bunker, etc.), uncheck this box. The latitude and longitude input fields become available. When this platform is selected for a project, and

the platform is stationary, its location will automatically be copied to the project. You have the option to override the location from the project window if you choose to do so.

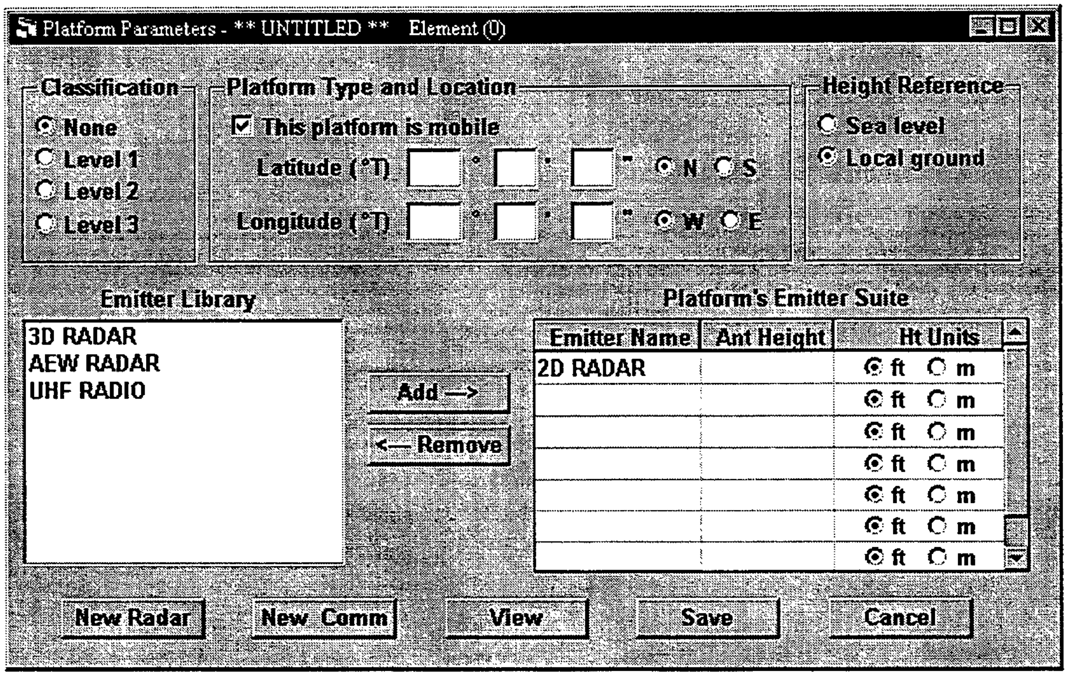


Figure 5-6: Platform window.

Height Reference

APM requires a reference level for antenna height considerations. The reference level may be the local ground level or mean sea level. For example, a land-based system mounted on a truck may use local ground level as the reference level, a shipborne system may use mean sea level as the reference level, and an airborne system may use either. As a convenience, the antenna height is copied from the platform database and placed in the project window so you may temporarily edit it. You may not change the reference level in the project window, however.

Emitter Library

The emitter library is a listing of all emitters in your current database. Use the list scroll bars to view all the emitters. To select an emitter, click on its *name* or use the navigation keys to position the cursor over its name and then press the ENTER key.

Platform Emitter Suite

The platform's emitter suite is a listing of all emitters currently on your platform. The first column shows the emitter name. The second column shows the height of the emitter's antenna. The third column shows the units of antenna height. When a platform

is selected from the Project window, the emitter names within the suite will be copied into the Radar/Communications dropdown menus for your selection. For additional information about the link between the platform's emitter suite and the Radar/Communications dropdown menu, see chapter 6, the **Program Flow** item on the **Options** menu.

Command Buttons

Add Emitter

A listing of all emitters in your current database is shown in the emitter library list. To add a particular emitter to your platform's suite of emitters, highlight its name and then click the Add button.

Remove Emitter

A listing of all emitters in your current platform's suite is shown in the suite list. To remove a particular emitter from your platform's suite of emitters, highlight its name and then click the Remove button.

New Radar

Normally you add radars into your database by using the **System** menu. You may also add a radar to the database by selecting the New Radar button. After the radar has been added to the database and the radar system window is closed, its name will be added to the emitter library list and you may then add it to the platform's emitter suite.

New Comm

Normally you add communications systems into your database by using the **System** menu. You may also add a communications system to the database by selecting the New Comm button. After the communications system has been added to the database and the communications system window is closed, its name will be added to the emitter library list and you may then add it to the platform's emitter suite.

View Emitter

While creating your platform, you may want to examine the parameters for the emitters currently on your platform. By selecting the View button, a separate window for each system will open. You may use the **Windows** menu to tile the windows in various manners. You may also edit any of the system parameters from any of the system windows. If you edit a system, however, be sure to **Save** the system before closing its window.

Radar Window

The radar window, figure 5-7, opens by selecting New Radar or Open/Remove Radar from the Systems menu.

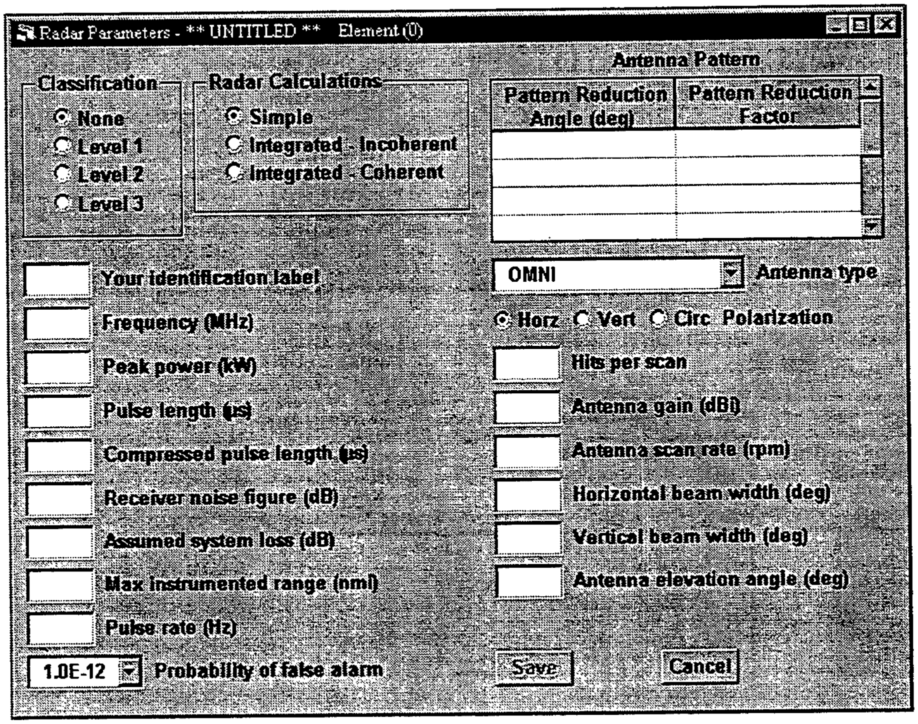


Figure 5-7: Radar window.

Radar Calculations Options

Detection of a target requires the receiver output, which consists of signal and noise, be processed in such a way that true signal detection is of high probability and that false signal detection (due to noise or jamming) is of low probability.

The probability of detection is determined by the amplitude distribution (envelope) of the signal plus the unwanted noise or jamming. To improve the probability of true signal detection, pulse integration (the adding of target return signals and noise from two or more successive transmit pulses) is often performed. The advantage of pulse integration is that the true signal often does not change very fast (within a 10th of a second or so) whereas noise, a random process, often changes from pulse to pulse. Therefore, using integration normally allows the true signal to grow in strength (giving a better probability of detection), whereas the noise typically decreases in strength (its average value is zero).

There are two types of radar signal integration: coherent and incoherent. Radar signals are said to be coherent when the relative phase of the signals have a known relationship even though they may be considerably separated in time. Coherent integration is the addition of coherent radar signals (signals in relative phase) prior to determining the detection envelope. Incoherent integration does not consider the signal's phase but examines only the amplitude of each individual pulse. Once the amplitude information is extracted for each pulse, the information is then summed. Coherent integration increases the probability of detection more rapidly than incoherent integration, but coherent integration is normally more expensive to implement.

AREPS allows for the calculation of a detection threshold based upon coherent integration, incoherent integration, or no integration (simple).

EM System Parameters

Your Identification Label

The identification label is an optional field for your own use in organizing your radar systems. This label shows in the **Details** view of the Open/Remove window. By clicking on the identification label column title bar, your radars will be sorted by this label, allowing you another way to quickly find a particular radar. You may use any label format you desire but the label is limited to 12 characters.

Frequency

Frequency is the rate of recurrence of an event in periodic motion. The frequency is defined as the speed of light propagating through the atmosphere, divided by the wave length of the transmitted energy. For radars and communications systems, this data input is the frequency of the transmitter. For a target, it is the frequency corresponding to the measured radar-cross section. For an ESM receiver, it is the upper and lower frequencies associated with a particular receiver band.

The recommended limits for all frequencies are 100 to 20,000 MHz. The units may be MHz or GHz. While the parabolic equation technique of APM is capable of higher frequencies, we have set a hard upper limit of frequency to 57 GHz. This is because APM version 1.0 has only implemented the gaseous absorption model up to that frequency.

Peak Power

For a radar application, the peak power is the maximum instantaneous power generated in a single pulse by the transmitter. Do not include transmission line or other losses. Do not use average power. For a communication application, use the average power.

Pulse Length

In nature, energy is typically transmitted in the form of a simple sine wave. A radar transmitter will generate, in short bursts or pulses, this sine wave and then vary (or modulate) its frequency or phase, thereby shaping the waveform. A shaped waveform will increase the information that may be obtained from the return echo. The pulse length is the length of time between the start and end of the pulse. Long pulse lengths have the advantage that large amounts of energy can be applied to a target in order to enhance its detectability. Long pulse lengths will lead to the longest range of detection and are, therefore, used in long-range search radars. Long pulses have the disadvantage that fine details within the return echo are lost, thereby reducing target resolution. For example, a long pulse length may be used to detect the presence of a harbor within a coastline but will be unable to detect a pier within the harbor.

Compressed Pulse Length

Many receivers perform sophisticated signal processing to aid in identifying a true target or gaining additional information about the target. One such technique is called pulse compression. By modulating a wave's frequency or phase, the echo may be compressed in time by the receiver. Pulse compression achieves the benefit of high target resolution that comes from using a short pulse length yet uses the energy of a long pulse, gaining longer range detectability. In addition, pulse compression also reduces the influence of clutter. AREPS version 1.0 does not consider surface clutter and, therefore, pulse compression is not a required input. When a future version of AREPS does consider surface clutter, the pulse compression input will be activated.

Receiver Noise Figure

The receiver noise figure (most accurately described as a system noise figure) is a measure of the receiver system's noise temperature. The temperature relates to thermal noise in the receiver circuit, non-thermal noise from the electronic components, and antenna noise from environmental sources. The noise figure is defined by the ratio (in decibels) of the system noise temperature in Kelvin to 290° Kelvin (the IEEE standard reference temperature).

Assumed System Loss

The system loss is the sum of all losses that affect the radar free-space range calculations. These include, but are not limited to, transmission line loss, beam shape (or antenna pattern) loss, filter mismatch loss, bandwidth correction factor loss, signal processing loss, collapsing loss, etc.

Maximum Instrumented Range

After the transmitter sends out a pulse, it turns off and allows the receiver to "listen" for an echo. It may happen that a pulse will travel to a target and back, only to arrive while the transmitter is in the process of sending out another pulse. In such an

event, the pulse is not received and the target is not detected. It may also happen that the pulse will return at some time after the transmitter has sent out a second pulse. In that circumstance, the target will appear closer to the transmitter than it really is. Echo signals received after an interval exceeding the pulse repetition period are called "multiple-time-around" echoes or "radar ghosts." The range that a pulse can travel to the target and back in the time interval between pulses is known as the maximum instrumented range or the maximum unambiguous range.

Pulse Rate

The pulse rate is the number of pulses the transmitter generates each second.

Probability of False Alarm

Receivers are designed with a high enough detection threshold that most receiver noise will not exceed it. On occasion, however, noise will have sufficient power to exceed the threshold, resulting in a false alarm. A tolerable rate at which false alarms occur depends upon the nature of the radar application. False alarm probabilities for most practical radars are quite small, on the order of 1.0E-6 or smaller.

Antenna Pattern

The distribution of energy into space relative to the antenna's axis of symmetry is called the "antenna pattern," its "power pattern," or its "radiation intensity pattern." While the distribution of energy is in three dimensions, it is most commonly displayed as a series of two-dimensional planar patterns. The major concentration of energy is along the axis of symmetry and is known as the main beam or "lobe." The main beam width, both horizontally and vertically, is most commonly expressed in degrees and represents the half-power points in the pattern. The additional lobe structure of the antenna pattern outside the region of the main beam is called "sidelobes." Sidelobes cause problems in target detection because they allow energy from outside the desired direction to enter the system. This leads to false targets or increased susceptibility to radar jamming.

For many radar applications, it is desirable to reduce the power output at higher beam elevation angles or, conversely, increase the power output for lower beam elevation angles. Height-finder radars commonly employ antennas that steer the transmitted energy upward in angle. While the power necessary to detect a target 200 miles away in the horizontal is desired, the same power directed upward at 30 degrees would detect a target at approximately 530,000 feet. Since targets are not expected at this height, the power of the transmitter is reduced as the elevation angle increases. In addition, there is a reduction in how long the receiver waits for a radar echo. This has the advantage of reducing the strain on the transmitter and allows for better utilization of the radar's time. For the HT-FINDER SPECIFIC antenna pattern you must specify, and for the USER DEFINED antenna pattern you may specify, the angle at which the power is reduced and the factor by which the power is reduced. For the other antenna types, the antenna pattern entries are not available.

Antenna Type

The antenna type provides a description of the radiation pattern of the transmitter or radar antenna. The antenna types as used in AREPS are given in table 5-2.

Table 5-2: Antenna types.

OMNI	Uniformly radiating in all directions
SINX/X	See **Elevation angle** for additional information
CSC-SQ	Cosecant-squared radiating pattern
GAUSSIAN	Gaussian radiating pattern
HT-FINDER GENERIC	Height-finder that vertically scans a SINX/X pattern
HT-FINDER SPECIFIC	Height finder with a radiating pattern defined by the radar itself like the AN/SPY-1B or the AN/SPS-48E
USER DEFINED	A radiating pattern you defined yourself

Polarization

Polarization is the orientation of the antenna's electric field, which may be parallel to the earth's surface (horizontal), or perpendicular to the earth's surface (vertical). The polarization may also be elliptical or circular. Elliptical polarization is the combination of two linearly polarized waves of the same frequency, traveling in the same direction, which are perpendicular to each other. The relative amplitude and phase relationships between the two may be of any value. If the two wave amplitudes are equal and they are 90 degrees out of phase, the polarization is circular. For the target, the polarization corresponds to a measured radar-cross section.

Hits Per Scan

In order to detect a target, an acceptable signal-to-noise ratio must be obtained. One way to accomplish this is to apply more energy on the target. Applying more energy on the target may be accomplished by increasing the number of pulses striking the target as the radar beam scans over the target. For simple radars, the number of hits per scan is calculated from the antenna's horizontal beam width, the pulse repetition frequency, and the horizontal scan rate of the antenna. For other types of radars, the number of hits per scan must be specified explicitly.

Antenna Gain

The ability of an antenna to concentrate energy into a particular pattern or be more sensitive to energy arriving from a specific direction is called antenna gain. The gain of the transmitting antenna is a function of the antenna's aperture (the physical area of the antenna face), any losses of energy from processes such as resistance and radiational heating, and the wavelength. As the aperture of the antenna increases, the wavelength of energy decreases and the antenna gain increases. Greater antenna gains, of course, mean better target detection. While most radars are fixed in size and, therefore, have fixed gains, it is possible to use the relative motion between the radar and the target to electronically increase the aperture of the radar, thereby improving the gain and resolution. These radars are called "synthetic aperture" radars (the motion of the radar is used to increase the gain) or "inverse synthetic aperture" radars (the motion of the target is used to increase the spatial resolution.

Antenna Scan Rate

The antenna scan rate is the transmitter's antenna rotational or horizontal turning rate.

Horizontal Beam Width

The horizontal beam width is the horizontal angular width between half-power points of the antenna's main beam.

Vertical Beam Width

The vertical beam width is the vertical width of the antenna's main beam. For SINX/X, GAUSS, and HT-FINDER, the beam width is the full angular width between half-power points. For CSC-SQ, the beam width is the angular region where the pattern is uniform and above which a cosecant-squared function is applied.

Antenna Elevation Angle

The antenna elevation angle is the boresight pointing angle for SINX/X and GAUSS antenna types. It is also the direction of the maximum radiated power. For the HT-FINDER (GENERIC) antennas, the elevation angle is the angle above which the SINX/X pattern is vertically scanned. The elevation angle is measured from the local horizontal and increases in an upward direction. For most surface-based systems, this angle will be zero. For many airborne radars, this angle will be slightly downward (negative elevation angle).

Communications Window

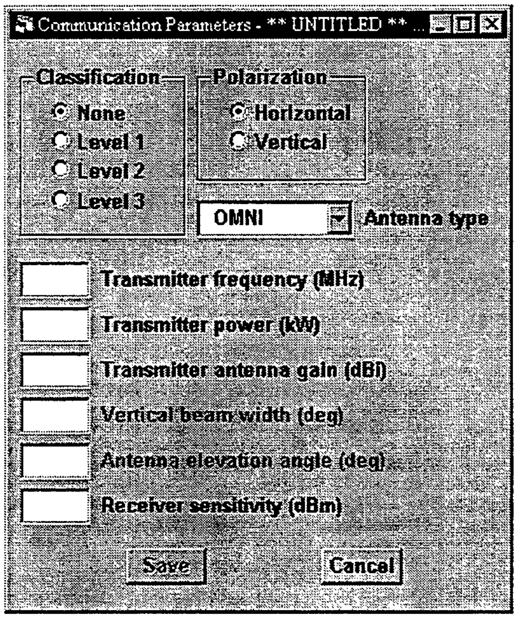


Figure 5-8: Communications window.

The communications window, figure 5-8, opens by selecting **New Communications** or **Open/Remove** Communications from the **Systems** menu. Refer to navigating the AREPS windows for a general discussion of data input, editing, etc. For a brief description of each input field or option item other than receiver sensitivity, see the corresponding term within the radar window discussion above.

Receiver Sensitivity

The receiver sensitivity is the measured or specified ESM or communication receiver's sensitivity in decibels above a milliwatt (dBm). For ESM receivers, each frequency range and polarization combination will have its own sensitivity. Sensitivity values are normally negative. A typical good ESM sensitivity for microwave frequencies is -80 dBm. The radar and ESM receiver parameters will determine the receiver sensitivity used for the project. If the radar and ESM receiver do not have the same polarization, the sensitivity will be reduced by 3 dB for horizontal or vertical polarization radar and circular polarization receiver, or by 15 dB for horizontal polarization radar and vertical polarization receiver (or vice versa).

ESM Window

The ESM window, figure 5-9, opens by selecting **New ESM** or **Open/Remove** ESM from the **Systems** menu. For a brief description of each input field or option item, see the corresponding term within the Radar or Communications window discussion above.

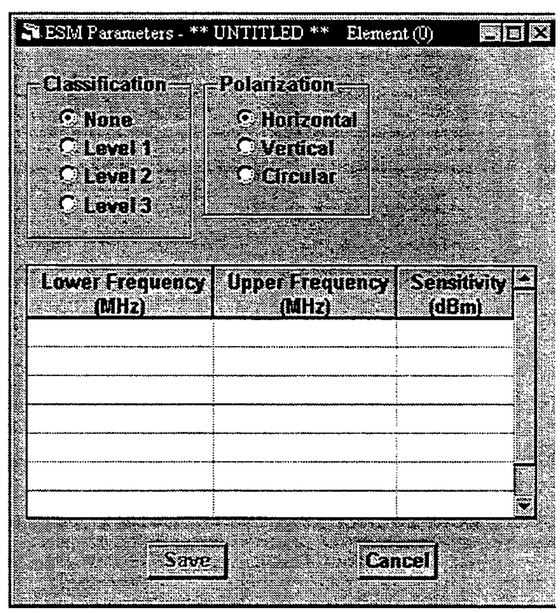


Figure 5-9: ESM window.

Target Window

The target window, figure 5-10, opens by selecting **New Target** or **Open/Remove** Target from the **Systems** menu. For a brief description of each input field or option item other than radar cross-section and Swerling case, see the

corresponding term within the Radar window discussion above.

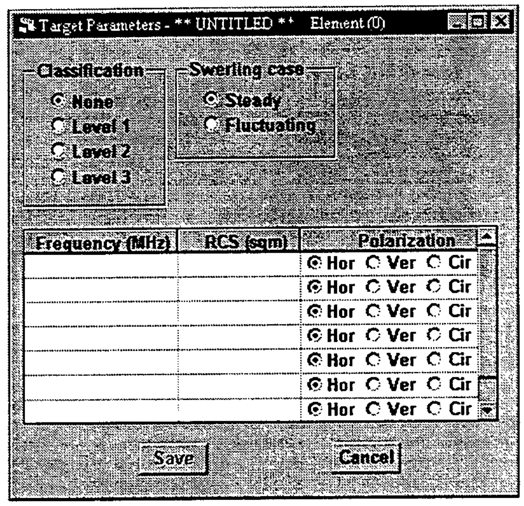


Figure 5-10: Target window.

Radar Cross-Section

A target's radar cross-section is a term used to describe the signal scattering efficiency of the target. It is a function of the target's shape, the materials it is made of, the angle at which it is viewed (which implies a range dependency), the radar frequency, and the polarization of the transmitting and receiving antennas. The units of radar cross-section are units of area. In early work, the common unit was the square foot, but currently the accepted unit is square meter. It also may be expressed in decibels relative to the standard. Thus, a target's radar cross-section may be expressed in decibels relative to 1 square meter.

The most direct way to determine the radar cross-section is to illuminate the target, or a scale model of it, with a well-calibrated radar and measure the return signal. Other ways are by direct solution of Maxwell's equations for the boundary conditions appropriate to the object (usually impossible for all but the simplest shapes) or by some approximation technique based upon EM theory.

For AREPS, you must specify the radar cross-section directly in addition to the associated frequency and polarization. For the purposes of AREPS, an air target is considered a "point source" target with a single cross-section. A ship is considered a "distributed target" and the radar cross-section (σ) may be approximated by

$$\sigma = 52\ f^{0.5}\ D^{1.5}$$

where f is the frequency in MHz and D is the ship's full load displacement in kilotons. Because the radar cross-section is a function of so many variables, it should never be extrapolated, inferred, or "guessed" from the cross-section of another target.

Swerling Case

Most real targets exhibit fluctuations in the radar cross-section. These fluctuations must be considered when computing the signal-to-noise ratio. In 1960, Swerling proposed four models for these fluctuations in radar cross section. His Cases 1 and 2 apply to a complex target consisting of many independent scattering surfaces, all of which are approximately the same size. His Cases 3 and 4 apply to a target that consists of one large reflecting surface with other small reflectors. For AREPS, only steady and Swerling Case 1 targets are considered. For Swerling Case 1, the fluctuation is negligible from pulse to pulse and uncorrelated from scan to scan. Case 1 may be typical of aircraft, while steady may be appropriate for ships. These selections will provide the most conservative value and will not produce an unreasonably high signal-to-noise ratio.

OPTIONS WINDOW

AREPS uses many global (used universally throughout the program) options that you have control over. These options are selected or specified from the various tabs of the options window. The options window opens by selecting **Options** from the AREPS main menu. Once the options window is opened, you may move between tabs, by clicking on the tab title, without having to return to the main menu. While the options window is open, you will not have access to any other AREPS window. The options window must be closed before you may proceed with any other activity.

Command Buttons

Across the bottom of the options tabs are command buttons which control how the options are applied. These command buttons behave the same for each tab.

OK Button

Click this button to accept all the option changes you have made on all the tabs and return to the main AREPS menu. If you don't save your changes prior to clicking this button, the changes will only be effective for the current AREPS session and the options will revert back to their prior settings the next time you use AREPS.

Save Button

Click this button to accept the option changes you have made on the current tab only. The new options settings are written into the AREPS initialization file so they may be active the next time you start the AREPS program. You will remain in the options window for additional changes on other tabs.

Cancel Button

Click this button to ignore all options changes on all tabs and return to the main AREPS menu.

Defaults Button

Click this button to restore all the options on the current tab back to the AREPS default values.

Reset Button

Click this button to reset all the options on the current tab back to the values they had when the options window was opened.

Folders and Drives Tab

The AREPS program uses a number of folders to help organize your data. The paths to these folders are established when you set up AREPS. You may change the folders after the initial setup from this tab, figure 6-1. To change the folder or drive, just type the new path in the input field. A discussion of each option follows.

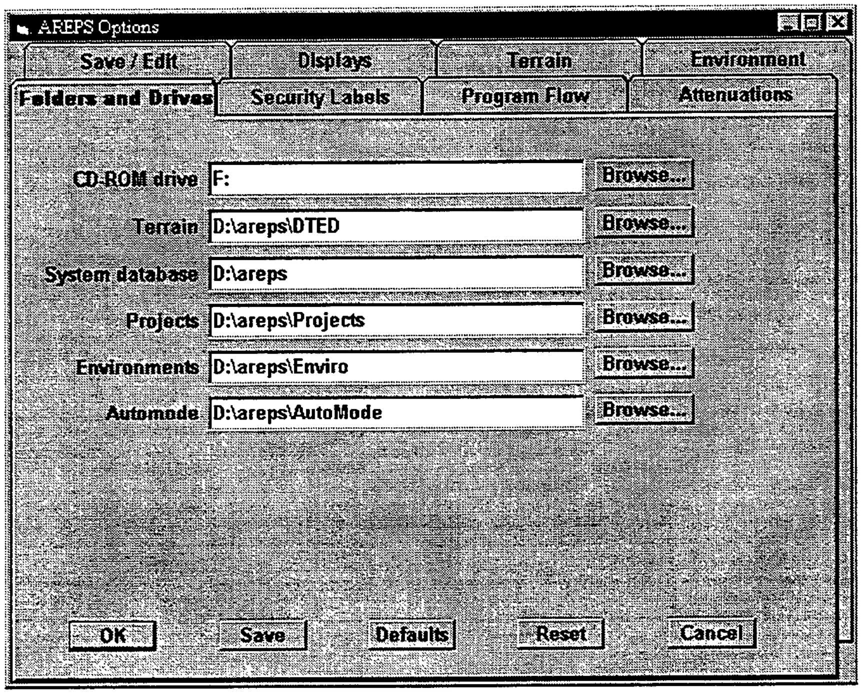


Figure 6-1: Folders and drives tab.

CD-ROM Drive

This is the letter of your CD-ROM drive. As you install new hardware drives, the letter of your CD-ROM may change. You may update your CD-ROM drive letter by entering a new value.

If you want to use a CD-ROM drive on another machine, the two machines must be networked. Refer to the Windows 95/NT user's manual for instructions on creating networks. Once you are on a network, you must properly map the drive before you may specify its name here. Once mapped, you may use the Browse command button to select the drive from the CD drive dropdown menu. Mapping the drive consists of two actions: sharing the CD drive on the server machine and mapping a shared CD drive on your machine.

▶ **Sharing the CD drive.**

1. From the Windows 95/NT Explorer Window, click on the Network Neighborhood icon and note the network name of the machine with the CD drive. In this example, it is Bali as illustrated in figure 6-2.

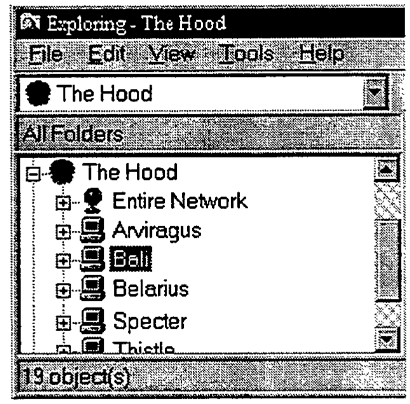


Figure 6-2: Network neighborhood.

2. From the Windows 95/NTExplorer Window, right click on the CD icon.

3. Select Properties from the popup menu.

4. Left click on the Sharing tab, illustrated in figure 6-3.

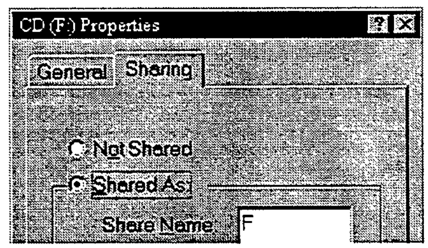


Figure 6-3: Asset sharing tab.

5. Select the **Shared As** option button. Note the name of the drive. For this example, it is F. You do not need to change it. You do not need to change any other options on this sharing tab.

6. Click the OK command button. When the properties windows closes, you will notice the CD icon now includes a small hand, indicating it is a shared asset.

▶ **Mapping the CD drive.**

1. From the Windows 95/NT Explorer Window, click on the Map Drive icon and a Map Drive window, figure 6-4, will open.

2. The Drive dropdown menu will show the next available drive letter on your machine. In this example, it is G. Accept this letter.

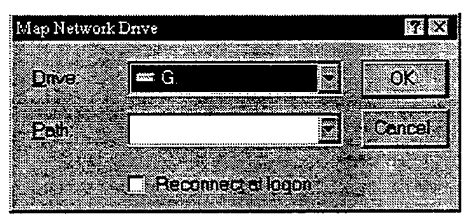


Figure 6-4: Map drive window.

3. In the Path dropdown menu, type the location of the CD drive using the Universal Naming Convention. The format of an UNC name is \\server\share. For our example, the UNC name is \\bali\f. Then click the OK command button.

Terrain Folder

This is the path to your DTED terrain folder. You may change it by entering a new path. Because hard disk access is usually much faster than CD-ROM disk access the data are optionally written (by default) to this folder for later use. As AREPS reads the terrain data from the DTED CDs, of course, this folder will grow in size as more data are required.

You are cautioned to watch the amount of disk space available, as low disk space will not only affect the AREPS program but all your other programs. If time is not a concern, you may want to delete the files within the folder every so often and let AREPS reread the data as required. If free hard disk space is always a problem for you, you may choose to have AREPS read directly from the CDs without copying the data to the hard disk. To do this, select the Terrain tab from the Options menu.

You may choose to create your own terrain file (or edit a DTED terrain file) in the terrain window. If the file is created in this fashion, the file will be saved in the environment folder, not the folder you specify here. When needed, it will be copied into the appropriate project's folder.

System Database Folder

By default, the EM system database resides in the AREPS main folder. You may choose however, to have your database elsewhere. For example, for security reasons, you may want your database to reside on a floppy diskette or a removable hard disk so you may store your database in a secure location when it is not being used. To change the database location, enter a new value.

Projects Folder

As you create projects, they are saved in projects folder. By default, this folder is called Projects and is a subfolder of the AREPS main folder. Each project will become its own subfolder of the project folder and will contain all the files (except for DTED terrain data) necessary for executing the project. To change the path to the projects folder, enter a new value.

Environments Folder

All the refractivity profiles you create through the environment window are kept in this folder. Your original WMO message data may be located on any disk or in any folder, however, including a network drive or folder. To change the path to your environment files, enter a new value.

Automode Folder

The automode function is not implemented in version 1.0. In future versions, automode will be an automatic product generator designed for your convenience in providing AREPS support to other people, or for you in producing the same series of decision aids on a routine basis.

Browse Command Button

If you are unsure of the folder to enter for any of the above options, you may click on the Browse button adjacent to the folder name input field. A folder and drive selection window, figure 6-5, will open allowing you to browse through your computer's folder and drive structure. You may browse disk drives to include the CD-ROM drive, any floppy or removable disk drive, or any network drive. Click the **Ok** button to accept your folder choice. Click the **Cancel** button to return to your previous input point without a folder choice.

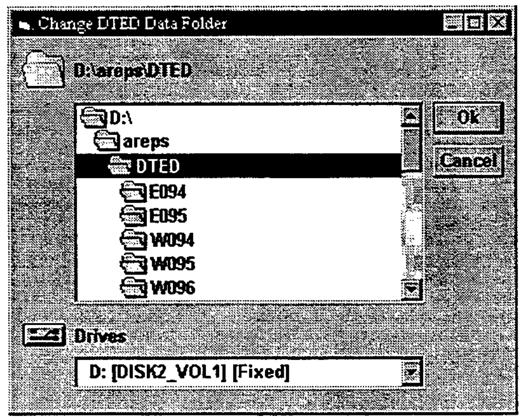


Figure 6-5: Change folder window.

Security Labels Tab

AREPS allows you to label your data with four different classification labels. The label definitions are assigned on the Security Labels tab, figure 6-6.

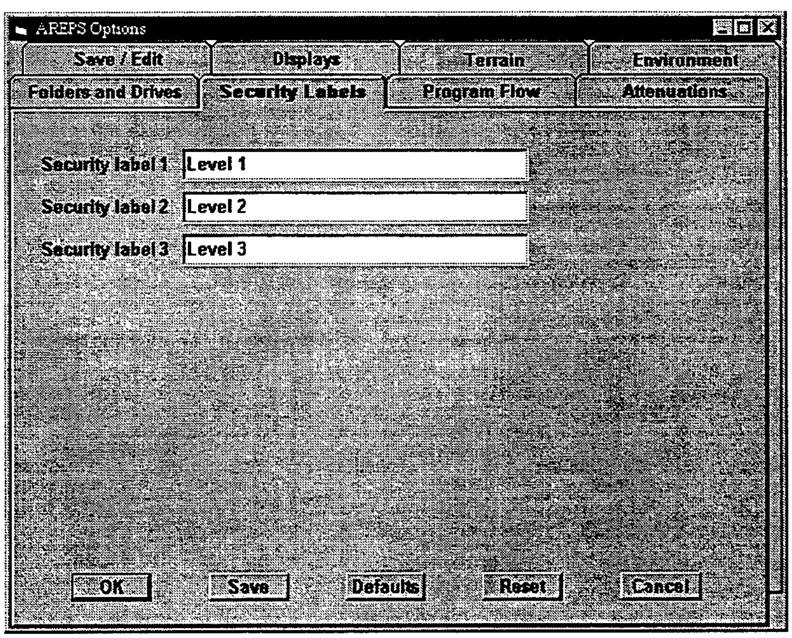


Figure 6-6: Security Labels tab.

Label 0 is predefined as None and you may not change it. You may change the text for labels 1, 2, and 3, however. For example, label 1 may be "My eyes only." To change the text for a security label, enter a new value.

It is your sole responsibility to adhere to the data security requirements dictated by higher authorities. This utility is strictly a convenience labeling feature and, as such, the AREPS developers assume no responsibility for unauthorized release of classified data or misuse of this feature.

Program Flow Tab

Many decisions need to be made concerning how AREPS flows, handles inadequate environmental data, and presents the EM database. Some of these decisions are made from this Program Flow tab, figure 6-7.

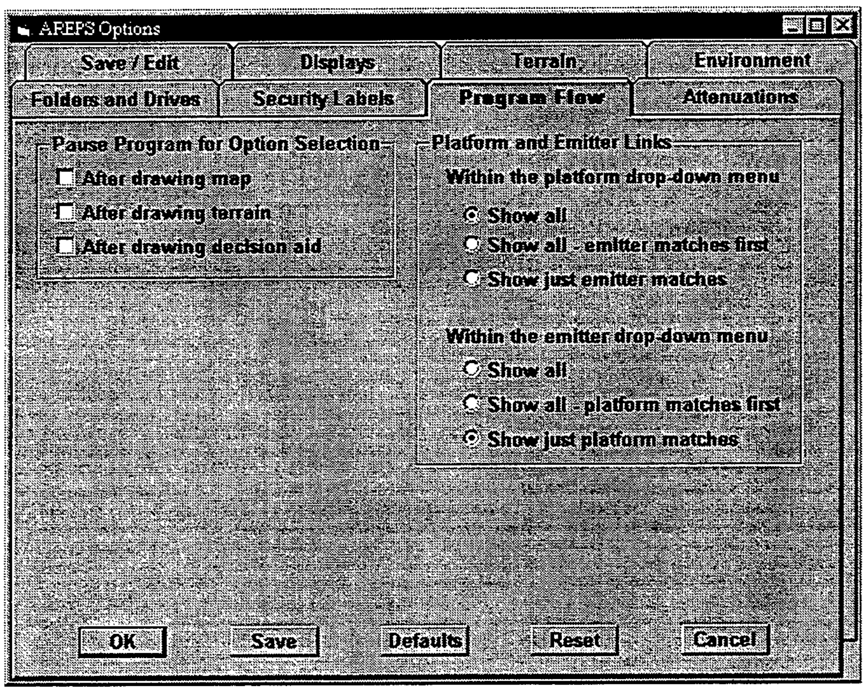


Figure 6-7: Program Flow tab.

Because of the multi-tasking feature of the Windows 95/NT operating system, you may have many AREPS projects active at any one time. These decisions are universal in that they apply to all the projects in the current AREPS session.

Pause Program for Option Selection

AREPS has numerous display features and options available. Many of these features and options are available from toolbars or right click popup menus. The Program Flow tab allows you to pause AREPS at various points to take advantage of these features and options.

Platform and Emitter Links

To help organize your EM systems, AREPS allows you to create platforms containing certain emitters. When you select a platform from the platform dropdown menu on the project form prior to selecting an emitter, the emitter dropdown menu will automatically be filled with the emitters on that platform. However, you may want to assess an emitter that is not on your currently selected platform and, for this case, the desired emitter is not available. From the program flow tab, you may choose how you would like AREPS to fill the emitter dropdown menu. You may have the emitter dropdown menu filled from just those emitters on the platform; filled first from those emitters on the platform (these names will be in capital letters) and then all the remaining emitters in the database (these names will be in small letters); or ignore the platform and fill the menu with all the emitters in the database.

As with the platforms, when you select an emitter before selecting a platform, the platform dropdown menu is filled with those platforms that hold your emitter. You may have the platform dropdown menu filled with just those platforms that hold your emitter; filled first with the platforms holding the emitter (these names will be in capital letters) and then all the remaining platforms in the database (these names will be in small letters); or ignore the emitter and fill the menu with all the platforms in the database.

Attenuations Tab

AREPS considers gaseous absorption in the calculation of propagation loss. Gaseous absorption is due primarily to atmospheric water vapor and oxygen. You may use this tab, figure 6-8, to choose how you would like AREPS to calculate the attenuation.

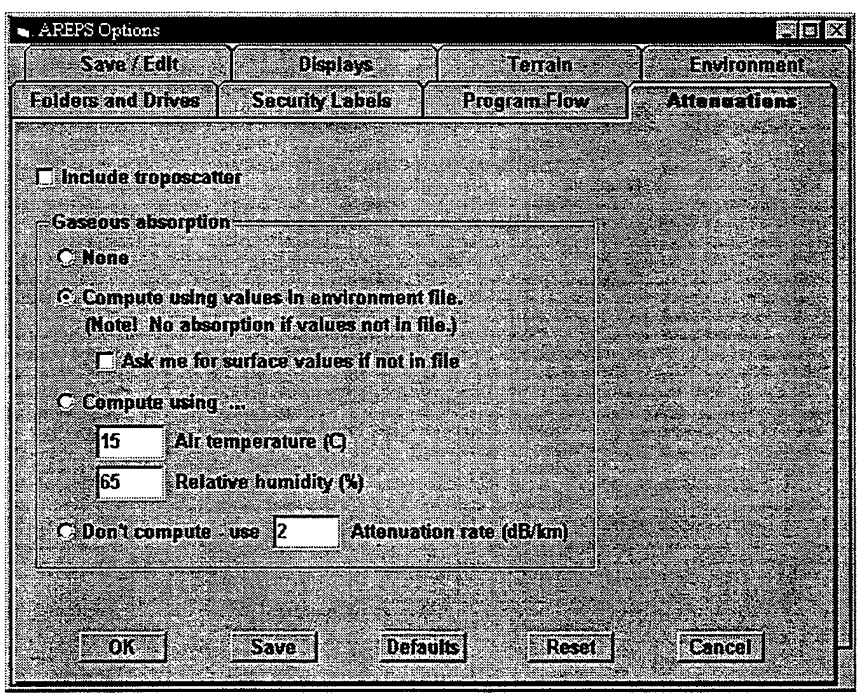


Figure 6-8: Attenuations tab.

You may choose not to consider gaseous absorption, to use meteorological observation data within your environmental file (AREPS automatically includes these data if you created your refractive profile from WMO observations), to enter a surface meteorological observation, or you may choose to directly enter a specific attenuation value. For the case of meteorological observations, you may enter surface temperature in Fahrenheit, Celsius, or Kelvin, and humidity as relative humidity, dew point temperature, dew point depression temperature, or absolute humidity. To change units and humidity types, right click on the input field's label for a popup units change menu. AREPS version 1.0 does not consider attenuation due to rain or fog. In addition, the gaseous absorption model is only implemented to a frequency of 57 GHz.

While not an attenuation, the option to include troposcatter in the propagation calculations is also found on this tab.

Save and Edit Tab

AREPS allows you to save propagation data in a number of formats in addition to simply displaying the decision aid. These data may then be used in your own research or in any other manner you choose. This tab, figure 6-9, allows you to specify how and where to save the propagation data. In addition, two other save and editing options are available.

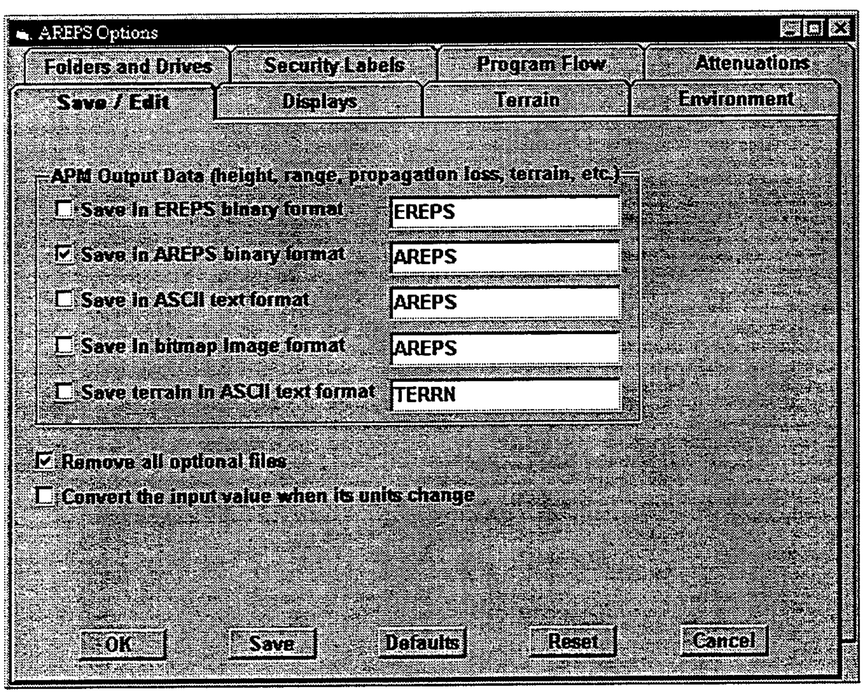


Figure 6-9: Save and edit tab.

APM Output Data Options

Save in EREPS Binary Format

For your own comparative studies or display purposes, you may want to use the propagation loss versus height and range data in the EREPS program. You may choose to have AREPS save these data in the project's folder in a temporary file readable by the EREPS program. By default, the file name is *EREPSddd.ebf*, where *ddd* represents the bearing degrees. However, you may choose a different prefix for the file name.

If you substitute another prefix for *EREPS*, remember EREPS is a series of MS-DOS programs and, as such, will not recognize Windows 95/NT long file names. For this reason, you may want to use names of five characters of less since AREPS will append the *ddd.ebf* to the file prefix you specify.

The binary data file format consists of three parts. Part 1 consists of optional ASCII comments. EREPS 3.0 ignores all ASCII data up to the first end-of-file, **eof**, mark. The **eof** has an ASCII code of 26 and may be generated from a BASIC language by printing CHR$(26) to the file. The **eof** must be followed by a carriage return, **cr**, and line feed, **lf**, combination. The **cr** has an ASCII code of 13, the **lf** an ASCII code of 10, and they can be generated from BASIC by printing CHR$(13) and CHR$(10), respectively.

Part 2 follows the **eof cr lf** combination of the optional ASCII comments, and consists of 14 lines of ASCII data containing the EREPS Version Label, file title, EM system, range, and height parameters. Each line of data is terminated by a **cr lf** combination. These 14 lines are given in table 6-1.

Table 6-1: ASCII text comment lines.

Comment Description	ASCII character format
EREPS Version Label	EREPS 3.0 **cr lf**
Title	up to 72 characters maximum **cr lf**
Frequency (MHz)	real number cr lf
Polarization	HORIZONTAL, VERTICAL, or CIRCULAR **cr lf**
Antenna height (m)	real number **cr lf**
Antenna type	OMNI, GAUSS, SINX/X, CSC-SQ, or HT-FIND **cr lf**
Vertical beamwidth (deg)	real number **cr lf**
Elevation angle (deg)	real number **cr lf**
Number of heights	Integer **cr lf** note: must be ≥ 1
Minimum height (m)	real number **cr lf** note: must be ≥ 1
Height increment (m)	real number **cr lf** note: must be > 0
Number of ranges	Integer **cr lf** note: must be ≥ 1
Minimum range (m)	real number **cr lf** note: must be > 0
Range increment (m)	real number **cr lf** note: must be > 0

Part 3 contains the binary data that follows the 14th **cr lf** combination of the ASCII data. The binary data consist of an array of propagation loss values in decibels times 10, rounded to the nearest integer. This maintains loss values to the nearest tenth of a decibel. The size of the array is equal to the number of height elements times the number of range elements times 2 bytes. The order for loss array values corresponds to all heights, from minimum to maximum, at the minimum range, followed by all heights at the next range, etc. Each integer array value is written in MS-DOS format, i.e., 2 bytes long with the low byte first. When writing the loss data to a file in a BASIC language, each element is separated by a semicolon to suppress the carriage return and line feed.

A sample Microsoft BASIC 7.1 program to create a binary file is illustrated by figure 6-10.

```
OPEN filename$ FOR OUTPUT AS #1
FOR i = 1 TO NumComments                  ' NumComments is number of
       PRINT #1, comment$(i)              ' comment lines
NEXT
PRINT #1, CHR$(26)                        ' eof cr lf
PRINT #1, "EREPS 3.0"                     ' Version Number cr lf
PRINT #1, Frequency                       ' Frequency cr lf
'    ....                                 ' similar statements for other
'    ....                                 '   variables described above
'    ....
PRINT #1, RangeIncrement                  ' Range Increment cr lf
FOR i = 1 TO NumRanges                    ' Number of range increments
     FOR j = 1 TO NumHeights              ' Number of height increments
          n =CINT(PL(i,j) * 10)           ' PL(i,j) = Propagation Loss at the
          PRINT #1, MKI$(n);              '    ith range and jth height.
                                          '    Use ; to suppress cr lf
     NEXT
NEXT
CLOSE #1
END
```

Figure 6-10: Sample Microsoft BASIC 7.1 program.

The MKI$ function ensures the integer is written in the MS-DOS format.

Save in AREPS Binary Format

As the mouse cursor moves about the decision aid, information about the decision aid (propagation loss values, height, range, etc.) shows in the status bar panels and in the labeling portion of the decision aid. In addition, the propagation loss versus range and

height displays also need this information. For rapid recall, this information is saved, by default, in the project's folder as a temporary binary format file. You may choose, however, not to save these temporary files if hard disk space is a concern for you. Be aware, if you choose not to save these files, options such as propagation loss versus range displays will not be available to you. We recommend you save these files.

By default, the file name is *AREPSddd.bin*, where *ddd* represents the bearing degrees. However, you may choose a different prefix for the file name. For example, you may choose to use "Jerry" instead of AREPS. You may use any valid Windows 95/NT file name character including spaces. AREPS will append the *ddd.bin* onto the file name you specify.

The AREPS binary file is used for rapid recall of propagation loss values and its use to you in other applications may be limited. Should you desire to use these propagation loss data for your own reasons however, table 6-2 describes the format of the binary file. In addition, we provide a sample Visual Basic program, illustrated in figure 6-11, to read the file.

Table 6-2: AREPS binary file format.

Offset	Size	Type	Variable name
1	2	2-byte Integer	X0 - Minimum range element
3	2	2-byte Integer	X1 - Maximum range element
5	2	2-byte Integer	Y0 - Minimum height element
7	2	2-byte Integer	Y1 - Maximum height element
9	4	4-byte Single	Rngmin - Minimum range in meters
13	4	4-byte Single	RngInc - Range increment in meters
17	4	4-byte Single	Htmin - Minimum height in meters
21	4	4-byte Single	HtInc - Height increment in meters
25	S where S = (X1-X0+1) * (Y1-Y0+1) * 2 bytes	2-byte Single	L(1,1), L(2,1), L(3,1), ..., L(440,1), L(1,2), L(2,2), L(3,2), ... - Propagation loss in centibels

This program reads the file and fills an integer array variable called LossArray. The array is dimensioned for the number of range (440) and height (384) screen pixels.

```
Fills Lossarray(Rngs,Hts) As Integer  ' Db values in picPlot Hts
Type ApmBinDataType                   ' Used in AREPSxxx.BIN files before
                                      ' LossArray(*,*)
    X0 As Integer                     ' Range elements of LossArray  Dimensions for
                                      ' LossArray(X0 to X1, Y0 to Y1)
    X1 As Integer
    Y0 As Integer                     ' Height element of LossArray
    Y1 As Integer
    RngMin As Single                  ' Range in meters of LossArray at X0
    RngMax As Single                  ' Range in meters of Lossarray at X1
    HtMin As Single                   ' Height in meters of LossArray at Y0
    HtMax As Single                   ' Height in meters of LossArray at Y1
End Type

Dim ApmBinData as ApmBinDataType
CH = FREEFILE
Open FileName For Binary As #Ch
Get #Ch, 1, ApmBinData
ReDim LossArray(ApmBinData.X0 To ApmBinData.X1, ApmBinData.Y0 To
                  ApmBinData.Y1) As Integer
Get #Ch, 25, LossArray
Close #Ch
```

Figure 6-11: Sample Visual Basic program to read AREPS binary file.

Save in ASCII Text Format

You may desire access to the propagation loss versus height and range data for use in your own evaluation program. Since many programs such as Microsoft Excel or The Math Works, Inc. MATLAB allow for import of ASCII text data, you may choose to have these data saved in the project's folder in an ASCII text file format.

By default, the file name is *AREPSddd.txt*, where the *ddd* represents the bearing degrees. However, you may choose a different prefix for the file name. For example, you may choose to use "Jerry" instead of AREPS. You may use any valid Windows 95/NT file name character including spaces. AREPS will append the ddd.txt onto the file name you specify.

The file contains header information to identify the project. Each piece of header information is preceded by a # sign. Following the header information is the number of range and height steps. These numbers are preceded by an @ sign and may be used as

counters for reading the data. Following the range and height step numbers are the loss data in centibels. The data are arranged such that there is one line of text for each range step. Within each line, the data are the loss values separated by a space. Each line of data is terminated with a carriage return and line feed character. An example of such a file is:

```
# AREPS Version [1.0.0] APM loss values
# Project parameters:
#    Project name: 3d surface radar
#    Emitter: 3D RADAR
#    Environment: Surface duct.env
#    Latitude:  118800
#    Longitude:  421200
#    Bearing: 090
#    Maximum range: (nmi) 50
#    Maximum height: (ft) 10000

# System parameters
#    Frequency (MHz):  3000
#    Antenna height (m):  22.86
#    Antenna pattern: Height-finder (Specific)
#    Antenna polarization: Vertical
#    Antenna beamwidth (deg):  2
#    Antenna elevation angle (deg):  0.5

# APM parameters
#    Minimum height (m):  0
#    Maximum height (m):  3048
#    Maximum range (m):  92600
#    Gaseous absorption (dB/km):  0
#    Troposcatter not considered

# Format of loss values is:
#   For each range step, loss values at each height step, cr , lf
#   -1 indicates no APM calculations
#   0 indicates no loss (ground)
#   xxxx indicates loss values in centibels

@  Range steps:  440
@  Height steps:  384

-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 3885 1537 1042 885 884 885 884 1127 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
```

1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -
1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 cr lf

Save in Bitmap Image Format

A bitmap image of the graphics is saved in the project's folder each time the project is executed. This image is just the portion of the decision aid inside the graphic axes. You may not prevent the saving of this image. The image name is *APMddd.bmp*, where *ddd* represents the bearing degrees.

You may choose to save the entire decision aid image to include the terrain map and all labels. The image may then be imported into a briefing package or printed for distribution. Remember, these files are bitmap images that will consume large amounts of hard disk space.

By default, the file name is *AREPSddd.bmp*, where the *ddd* represents the bearing degrees. However, you may choose a different prefix for the file name. For example, you may choose to use "*Jerry*" instead of *AREPS*. You may use any valid Windows 95/NT file name character including spaces. AREPS will append the *ddd.bmp* onto the file name you specify.

Save Terrain in ASCII Text Format

You may desire access to the terrain data for use in your own evaluation program. Rather than creating a program yourself to read the DTED CD-ROMs, you may have AREPS save the terrain's height and range data (one file for each project bearing) in the project's folder as an optional ASCII text file. By default, the file name is *TERRNddd.ter*, where the *ddd* represents the bearing in whole degrees relative to true north. You may choose to use a name prefix other than *TERRN*, however. You may use any valid Windows95/NT file name character including spaces. AREPS will append the *ddd* and the *.TER* extension onto the file name you specify. For example, if you specify *terrain.000*, the file name will be *terrain.000ddd.TER*.

Remove All Optional Files

By default, this option is set to true and is used to conserve hard disk space. When AREPS executes a project, the optional files discussed above may be created and placed into the project's folder. An example of such an optional file is the bitmap image of a coverage decision aid (*AREPSddd.BMP*, where *ddd* represents the bearing in whole degrees relative to true north).

As an example, you may want a project to save the decision aid images at bearings 000 degrees and 010 degrees so you can use them in a Microsoft PowerPoint presentation. The next time you execute the project, you may want the decision aid images at bearings 180 degrees and 190 degrees. By default, all the optional files from the previous execution are removed; that is, the image files associated with 000 and 010 decision aid are removed.

Removing optional files has no effect on a project's ability to display a previous execution.

Convert Values When Units Change

You may change the units of any input field by right clicking the mouse cursor on the label for the field. For example, to change the units of frequency right click on the word "frequency." If values are in a tabular form like the radar cross-section of a target, the units may be changed by right clicking on the label at the top of the column. By default, changing units will not affect the number within the input field. By checking this option, all numeric values will be converted to the new units when the units change.

When values are converted, they may be rounded and precision may be lost. Converting the value again could compound the rounding error. Therefore, converting back to the original units may not convert the value back to its original value. USE THE CONVERT UTILITY WITH CARE!

Displays Tab

AREPS tactical decision aids may be displayed in a variety of formats. You may choose the aid's display characteristics from this tab, figure 6-12.

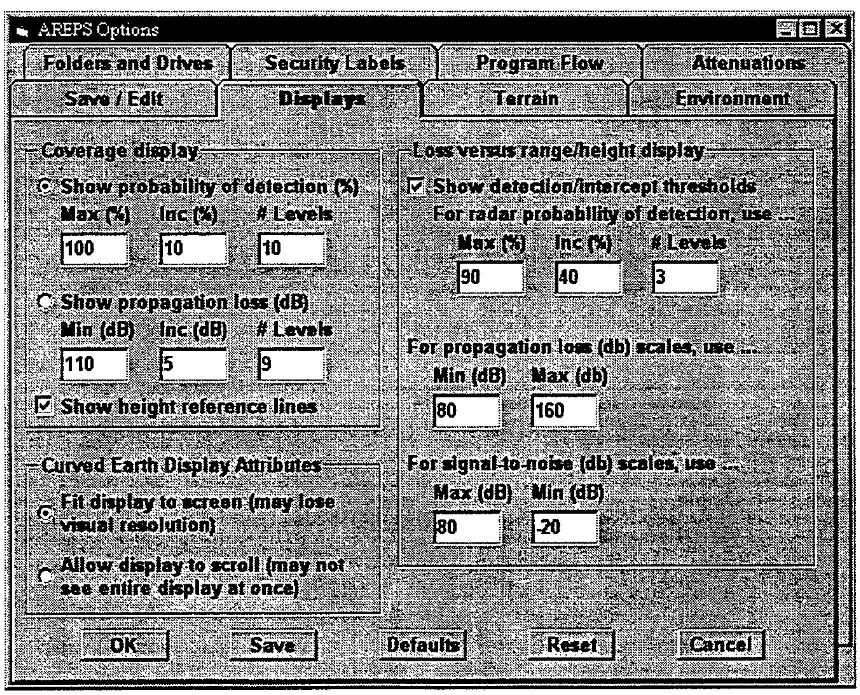


Figure 6-12: Displays tab.

Coverage Display

The height versus range coverage display may be referenced to radar probability of detection (or ESM/Communications threshold) or to propagation loss. You may specify the limit of this reference, the increment of the reference, and how many increments you want. For example, you may choose propagation loss as your reference. You then may select 100 dB as your minimum propagation loss threshold value, 5 dB intervals, and 9 intervals. On your display, you will see 10 boxes on the color bar labeled 0 to 100 dB, 100 to 105 dB, 105 to 110 dB, etc. As another example, you may have a radar project and choose radar probability of detection as your reference. You may then choose 100 percent as the limit, 20 percent as the interval, and 2 intervals. On the display, you will see two boxes on the color bar labeled 1 to .8 and .8 to .6.

To aid you in visualizing the decision aid, you may choose to have height reference lines on the display.

Loss Versus Range and Height Display

The loss versus range and the loss versus height display may be referenced to propagation loss or to signal-to-noise. You may specify the upper and lower limit of this reference.

In addition to the reference, you may also choose to superimpose radar probability of detection, ESM intercept, or communications threshold lines. For ESM only or communications displays, threshold lines will not display when using the signal-to-noise reference. For radar probability of detection, you may choose the maximum threshold, the interval of the threshold, and how many intervals you want. For example, you may choose 100 percent as the maximum probability of detection, 20 percent as the interval, and 2 intervals. On the display, you will see three colored dashed lines corresponding to 100, 80, and 60 percent probability of detection.

Curved Earth Display Attributes

You may choose the maximum height and range for your coverage decision aid in addition the type of surface depiction. These two options affect the two curved earth depictions and not the flat earth depiction. Because you are free to choose any height, range, and depiction combination, your selection could result in a great amount of scale distortion. Scale distortion makes the display hard to interpret or misleading upon casual inspection. To relieve some of this distortion, you may choose to have the display expand in the vertical dimension.

Expanding the vertical dimension, however, means you may not be able to see the entire display on the screen at one time. You would then have to use the vertical scroll bar at the right margin of the display to view the display. Using these options, you may force the entire display to appear within the window, or you may allow the display to

scale itself in the vertical. The advantage of having the entire display on the screen at one time is in capturing the screen to an external briefing package such as Microsoft PowerPoint. The disadvantage of course is the scale distortion.

Terrain Tab

AREPS allows for many terrain options, selectable from the terrain tab as illustrated in figure 6-13.

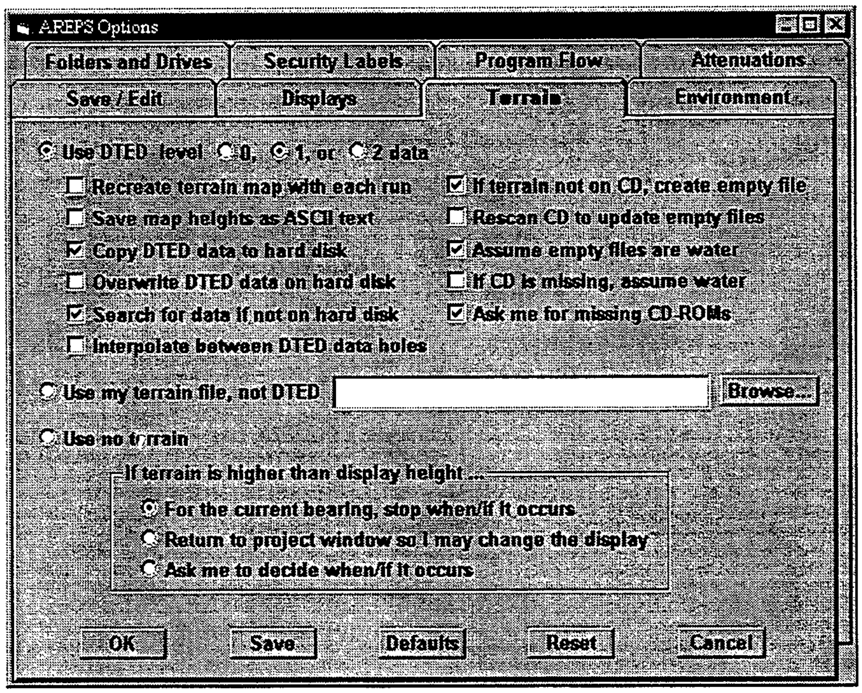


Figure 6-13: Terrain tab.

Which Terrain Data to Use

AREPS, as the default, uses digital terrain elevation data from NIMA. In addition to DTED terrain data, AREPS is capable of using terrain data you have specified yourself. You may use the terrain window to enter your own data and save it in a format usable by AREPS. Since these terrain data are stored in and read from an ASCII text file, you may also choose to create your own terrain data file external to the AREPS program using an ASCII text editor such as Notepad. Be sure to follow the specifications of an AREPS terrain file when making your own file in this fashion. Please understand, if you use your own terrain data, you will not see a terrain map image on the decision aid. You may also choose not to use terrain data. If your assessment is for a path entirely over water, you may want to choose this latter option.

Use DTED Level …

DTED are a uniform matrix of terrain elevation values, providing basic quantitative data for systems that require terrain elevation, slope, and/or gross surface roughness information. DTED data are provided in level 0, level 1, and level 2 formats. Level 0 spacing is 30 arc seconds in horizontal resolution (approximately 1 kilometer). DTED level 0 data are unlimited distribution and may be obtained directly from NIMA's public Internet homepage. Level 1 spacing is 3 arc seconds in horizontal resolution (approximately 100 meters). Level 2 spacing is 1 arc seconds in horizontal resolution (approximately 30 meters). Level 1 and 2 data are limited distribution. For this reason, DTED data are not and may not be distributed with AREPS. If you have a connection to the Secure Internet Protocol Router Network (SIPRNET), you may download the DTED level 1 and 2 data directly from NIMA's SIPRNET homepage. In addition, NIMA provides terrain data in other formats such as raster graphics. AREPS will accept DTED level 0, 1, and 2 coverage.

Other DTED Options

If you elect to use the DTED data, you have a number of additional options to choose from. These are:

Recreate Terrain Map with Each Run

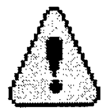
When a project is first executed, if you choose to have a terrain map, the map image is created from the data on the DTED CD-ROMs. The image is saved in the project's folder in a temporary graphic bitmap format file with the name *terrain map.bmp*. If the project is re-executed and this image exists, it is shown directly without recreating it from the DTED terrain data. You may, however, have changed the latitude and longitude between the first execution and the next and, thus, the map image will be out of date. You may choose to have the map image recreated every time the project is executed.

Save Map Heights as ASCII Text

When a project is first executed, if you choose to have a terrain map, the map image is created from the data on the DTED CD-ROMs. If you want these data for your own use external to AREPS, you may choose to have these height and range data saved in the project's folder in a temporary ASCII format file. The file name is fixed as *terrain map.dat*. Please understand this may be a very large file.

Copy DTED Data to Hard Disk

Because hard disk access is usually much faster than CD-ROM disk access, the data are written (by default) to the terrain folder for later use, as AREPS reads the terrain data from the DTED CD-ROMs. Of course, this folder will grow in size as more data are required. If free hard disk space is always a problem for you, you may choose to have AREPS read directly from the CDs without copying the data to the hard disk.



You are cautioned to watch the amount of disk space available as low disk space will not only affect the AREPS program but all your other programs. If time is not a concern, you may want to delete the files within the terrain folder every so often and let AREPS reread the data as required.

Overwrite DTED Data on Hard Disk

When the project requires DTED terrain data, it will first look in the terrain folder before looking elsewhere. If the proper terrain file is found, its data are used. In the course of time, you may obtain updates to the DTED CD-ROMs. If the terrain files are already in the folder, the new CD-ROMs will never be looked at. You may choose to have AREPS read the new CD-ROMs and overwrite the old data with the new.

Search for Data if not on Hard Disk

When the project requires DTED terrain data, it will first look in the terrain folder before looking elsewhere. If the data are found, they are used. If the data are not found, you may choose to have AREPS automatically search the CD-ROM. If the data are found, they are used. If the data are not found, AREPS will assume the terrain heights to be zero.

Interpolate Between DTED Data Holes

While the DTED CD-ROM may contain a terrain file for a particular geographical location, a specific latitude and longitude within the file may have missing height data. You may choose to have AREPS interpolate between height data present in order to provide a height for the missing location. Please understand interpolation may not necessarily be the correct procedure to provide missing information. As the terrain profile draws on the decision aid, you may examine the data to insure you feel comfortable with the interpolation. In cases where missing data is assumed to be water, heights will be zero, and no interpolation will occur.

If Terrain not on CD, Create Empty File

In some cases, the DTED CD-ROM may not contain a file for a particular geographical location. You may examine the map on the CD-ROM liner notes to see which locations are missing. If the file is missing from the CD, an empty file is written to the terrain folder on your hard disk as a placeholder. The empty file will be filled with heights of zero. Having the empty file present saves AREPS time by not having to look for a file already determined to be missing and also allows AREPS to skip asking you to enter the proper CD-ROM.

Rescan CD to Update Empty Files

The DTED CD-ROM may not contain a file for a particular geographical location. You may examine the map on the CD-ROM liner notes to see which locations are missing. If a missing file is encountered as AREPS is copying the data from the CD-

ROM to the hard disk, an empty file is written on the hard disk as a placeholder. The empty file will be filled with heights of zero. In the course of time, you may obtain updates to the DTED CD-ROM and previously missing files may now be present. You may have AREPS reread the CD-ROM to replace the empty placeholder files with files containing actual elevation data.

If CD is Missing, Assume Water

For whatever reason, you may decline to provide the DTED CD-ROM when requested, or you may choose to have AREPS just ignore any DTED data. If the CD-ROM is not provided, an empty file is not created. Since AREPS requires a surface elevation, an elevation of zero is used. You may choose to have AREPS assume this zero elevation means the surface is water. If so, the terrain map will be colored blue at these zero heights. If water is not assumed, the terrain map will be colored black at these zero heights. As the mouse cursor moves over the terrain map, assumed water will show a height of zero and no assumed water will show a "no height data" message in the label area of the decision aid. In cases where the surface is assumed to be water, heights will be zero and no interpolation will occur.

Assume Empty Files are Water

If a terrain file should be on a DTED CD-ROM but for some reason is not, AREPS will write an empty file to the terrain folder on your hard disk as a placeholder. The empty file will be filled with heights of zero. In most cases, if the file is missing from the CD-ROM, it is because the entire file's geographical area is over water. However, this is not always true. You may examine the map on the CD-ROM liner notes to see which missing locations are actually over water. You may choose to have AREPS assume an empty file represents water. If so, the terrain map will be colored blue at these zero heights. If water is not assumed, the terrain map will be colored black at these zero heights. As the mouse cursor moves over the terrain map, assumed water will show a height of zero and no assumed water will show a "no height data" message in the label area of the decision aid. In cases where missing data are assumed to be water, heights will be zero and no interpolation will occur.

Ask Me for Missing CD-ROMs

If you choose to use DTED terrain data, the project will first look in the terrain folder for the data. If they are not found, it will, optionally, look for a CD-ROM. You may choose not to have AREPS prompt you to enter the required CD-ROMs. You may want to do this if you do not have the CD-ROMs in the first place. If you elect not to be asked, terrain heights will be zero. Refer to the missing CD option for additional information about terrain heights of zero.

If Terrain is Higher Than Display Height

If you use DTED terrain data or your own terrain data, the maximum display height should be above the highest elevation of any terrain within the scope of the

project. Since the terrain elevation is not known until the project starts executing, a decision needs to be made about how to proceed, if your maximum display height is below the terrain elevation. You may have the decision aid stop at the range where the terrain exceeds the display height or you may return to the project window and change the maximum height. You may also have the project pause and ask you for your decision when or if the event occurs.

Environment Tab

The environment tab, figure 6-14, provides options when your environmental file does not meet AREPS' needs for the decision aid.

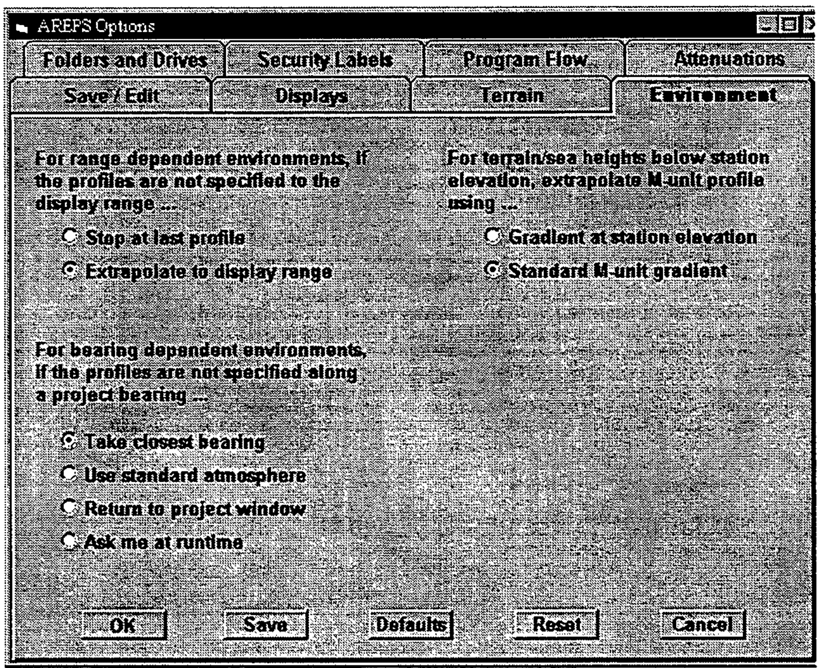


Figure 6-14: Environment tab.

Lack of Environment Data in Range

For range dependent environments, you should have the environment fully specified to the display range. If it is not, a decision needs to be made about how to proceed. You may have the decision aid stop at the range of the last environment specification or you may have the last specification extrapolated to the display range. In the case of the latter, your environment will be horizontally homogeneous (not range dependent) from the range of the last specified profile to the display range.

Lack of Environment Data in Bearing

For bearing dependent environments, you should have the environment fully specified at each project bearing. If an environment is not specified at a project bearing, a decision needs to be made about how to proceed. You may have the decision aid use the environment at the closest bearing, use a standard atmosphere environment, or return to the project window so you may either change environment files or edit the current environment file (external to AREPS) to include the necessary bearing information. You may also have the project pause and ask you for your decision when or if the event occurs.

Lack of Environment Data in Height

You must have your environment specified from the minimum display height to the maximum display height. If the first height specification is above this minimum height, a decision needs to be made about how to proceed. For example, your project's minimum height is 1000 feet below mean sea level and you are evaluating a system in the area of the Dead Sea. The radiosonde station elevation is 730 feet below mean sea level. For this case, you are missing the environment data for the heights between –730 feet and –1000 feet. To provide these data, AREPS must extrapolate from the radiosonde station elevation downward. The extrapolation techniques may either use a standard atmospheric gradient or use the gradient between the first (WMO surface group – 00XXX) and second height (WMO first significant level group – 11XXX) levels in the specification.

For station elevations above mean sea level and, if necessary, the environmental file creation routines within the environment window will automatically extrapolate the sounding to 0 meters (mean sea level). The extrapolation technique you choose here is used.

THE ENVIRONMENT

Environment Window

The environment window, figure 7-1, opens by selecting an input method from the AREPS menu. Across the top of the environment window is a toolbar with standard Microsoft icons, illustrated and described in table 7-1. Below the toolbar is a tab control that you may use to select how you will create the environment file.

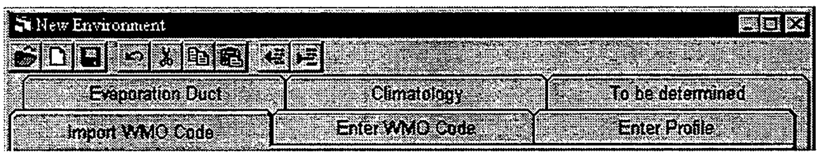
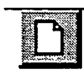
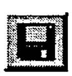


Figure 7-1: Environment window.

Table 7-1: Environment window toolbar icons.

Toolbar icon	Action
	The New toolbar button clears all the tabs of previously entered data so you may create a new environment file without having to leave and reenter the environment window.
	The Open toolbar button opens a file containing an environmental observation. To function correctly, the file's contents must be radiosonde data in standard World Meteorological Organization (WMO) TEMP, TEMP SHIP, or TEMP MOBILE format.
	The Save toolbar button or the Save or Save As items from the AREPS file menu will create an environmental input file readable by AREPS. In addition to the height and M-unit profile, all data used in creating the profile are also saved within the file. Once saved, you are returned to the AREPS main menu.
	Perform editing functions such as undo, cut, copy, and paste.
	Insert or delete levels within a profile.

As an aside, an environmental file may be created using any text editor program such as Notepad or by using any of the environmental input methods within the EREPS "RAYS" program. Any file created with these methods must follow certain conventions as discussed under the environmental file format section. The EREPS program complies with these conventions. Once created, the environmental file must be copied to the environment folder of AREPS in order to be included in the project's environment dropdown menu.

AREPS requires an environmental specification at all heights, ranges, and bearings of the project. In some cases, the specification may not be sufficient for the display characteristics you select. For these cases, you may choose how you would like AREPS to handle the lack of data. You make these choices on the **Environment** tab from the **Options** window.

Common Input Fields

Common to all tabs except the climatology tab are a number of input fields. These are:

Environmental Label

The label helps identify the environmental input. You are limited to 16 characters including spaces. If you are using either the Import WMO Code or Enter WMO Code tabs, a label for your environmental file will be automatically created from the WMO date/time code group. Since the month does not occur within the code, the month from the current computer time will be used. You may edit or delete this label as you wish.

WMO Station Type

If WMO code is entered by reading the data from a file or pasting from the clipboard, the data header UUBB (ship), TTBB (fixed location land), or IIBB (mobile location land) will determine which type of radiosonde station is being used. Once the station type is determined, you may not change it on any of the tabs. If you are using the Enter WMO Code tab, you may select the appropriate option button to alter the tab form to account for the differences between land and ship WMO code formats. If you are using the Enter Profile tab, you must specify the station type by selecting the appropriate option button.

If a land station is selected at any point, you will have access to the Evaporation Duct tab. However, you will receive a warning about appending an evaporation duct onto a land station profile. Normally, you should only consider this when the station is located at the coast and the meteorological conditions are such that the land station reflects the conditions over the water.

Station Elevation

If the radiosonde launch height is provided, it may be entered into the station elevation input field. For example, if the data were obtained from a radiosonde launched from the flight deck of an aircraft carrier, the flight deck height would be used for the station elevation. If necessary, a zero height level will be extrapolated using the M-unit gradient between the first two profile levels.

Profile Legend

The profile legend describes the current state of the environment and your inputs. If a valid height versus M-unit profile exists, the legend will read "Profile OK." If not, the legend will read "No profile." If an individual input value is unacceptable (i.e., a negative Kelvin temperature), its input field's background color will show red. If an individual input value is within bounds but not recommended (i.e., an evaporation duct height greater than 40 meters), its input field's background color will show yellow.

Import WMO Code Tab

If WMO code data are available within a file or are available upon the Windows clipboard, select this tab as illustrated in figure 7-2.

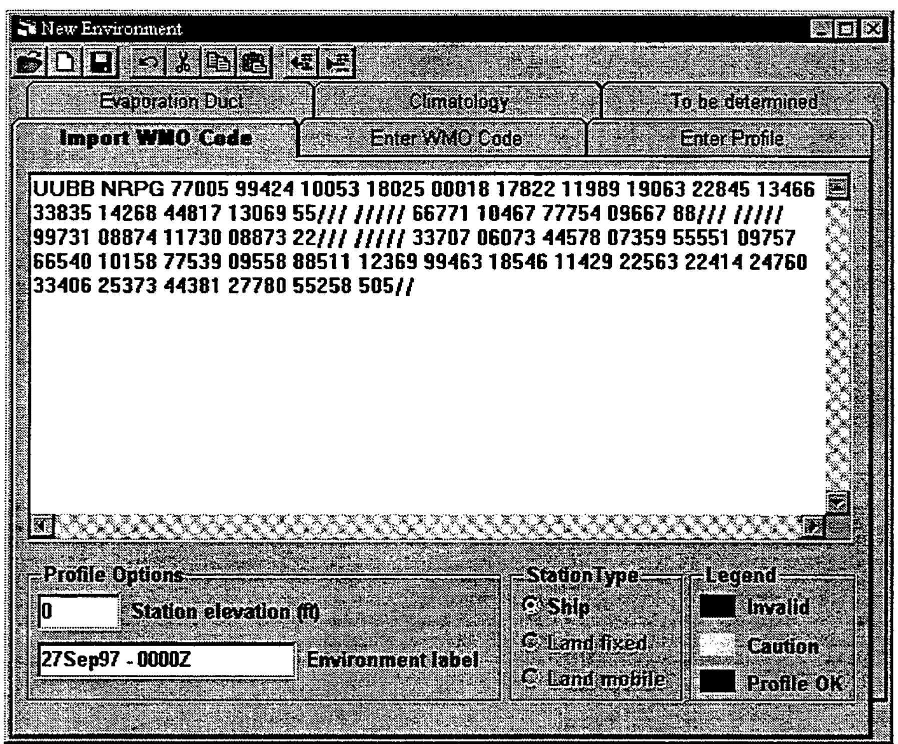


Figure 7-2: Import WMO Code tab.

If the data are in a file, you may open and read its contents directly using the Open toolbar button. Alternatively, you may drag and drop the file name from the Explorer window into this tab. The file may be located on any drive (network, your own hard drive, or a floppy diskette). If the data are available upon the Windows clipboard, you may paste them into the tab by using the Paste toolbar button, the AREPS edit menu, the right mouse click menu, or the standard Windows keystroke commands. As an example of this technique of data import, access the SIPRNET or Internet homepage of an organization that provides the local upper air observation in WMO format. While still in your Internet browser, highlight the WMO text and Copy it onto the clipboard using the browser's or standard Windows commands. Then left click in the import data text box and perform the Paste procedure.

The contents of the data may include text other than standard WMO code text. It is not necessary to edit the data to eliminate extraneous text prior to opening it with the AREPS program. Standard WMO code conventions are observed when parsing data. For example, if the text "UUBB", "TTBB", or "IIBB" is not found within the data, the data will not be processed.

Error checking is performed as the data are processed. If an error is found, it will be highlighted in the data input field. You may then use the editing toolbar buttons or the standard Windows editing shortcut keys (found on the right mouse button click menu) to correct any errors.

Once the data have been processed, you may select any of the other tabs to view them. Viewing the data prior to saving the profile is not necessary. Viewing the refractive condition descriptions on the Enter Profile tab, however, would alert you to possible errors in the processed WMO code. For example, poorly ventilated radiosondes will often show the top of a superrefractive, subrefractive, or trapping layer to be at a pressure of 1000 millibars.

Once WMO code is processed from a file or the clipboard, you may edit the data within any field within any tab.

You must be cautioned in the use of these data for several reasons. Since the data are most often obtained from a radiosonde launched over a land mass, the changing synoptic meteorological conditions must be evaluated to ensure the sounding is appropriate for the area and time of operation. For example, you should reject an early evening sea-breeze sounding if nighttime land-breeze conditions are present. Second, the actual data within the sounding should be investigated. Often digits can be transposed whether during the recording of data or during radio transmission. While AREPS does some gross error checking of the data, it is highly recommended that the data be examined and evaluated for meteorological consistency and accuracy.

Enter WMO Code Tab

If WMO code is available from a source other than a file or upon the Windows clipboard, select this tab as illustrated in figure 7-3.

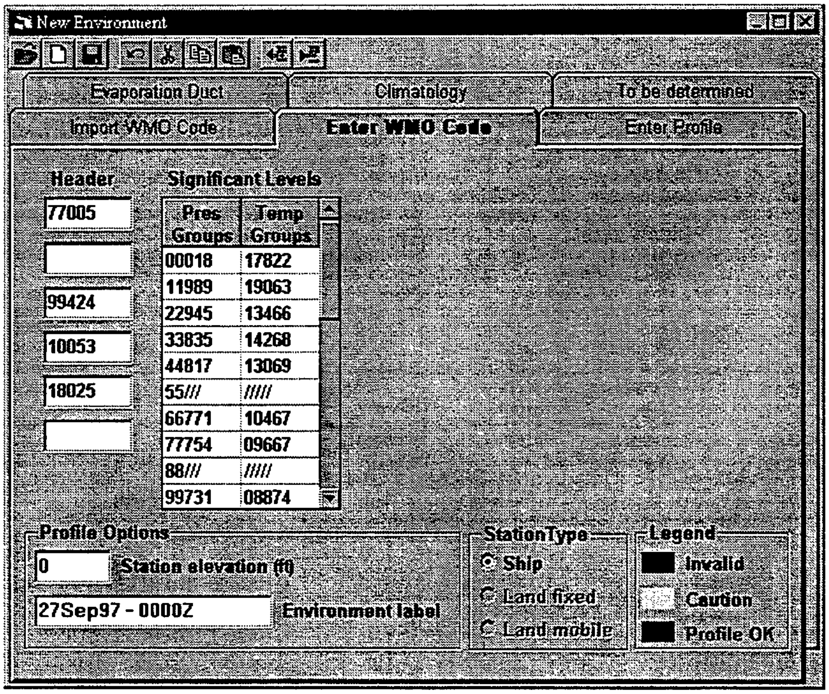


Figure 7-3: Enter WMO Code tab.

Input error checking is performed as data are entered. The editing toolbar buttons, the AREPS edit menu, or the right mouse click menu will work for any field within this tab. The remove or insert level toolbar buttons will not function from this tab.

The WMO code tabular form will accept an unlimited number of significant level groups. In using radiosondes to measure the vertical profiles of temperature and humidity, the absolute accuracy of the data is not as important for refractivity assessment as accurate measurement of the gradients. These necessary gradients are all found within the significant level portion of the WMO radiosonde report (IIBB, TTBB, or UUBB). For this reason, the mandatory levels of the radiosonde report (IIAA, TTAA, or UUAA) should not be necessary for refractivity assessment since any mandatory level that is also significant will appear within the TTBB, UUBB, or IIBB section of the report. Thus, AREPS does not consider the mandatory sections because these data are not needed. Should you feel it absolutely necessary to include the mandatory level data, you may insert them into the appropriate place within the significant level order.

While header input boxes are include for completeness, it is not necessary to provide this information.

Enter Profile Tab

If heights and refractivity values are known, or if pressure, temperature, and humidity values are known, you may use this entry method tab as illustrated in figure 7-4.

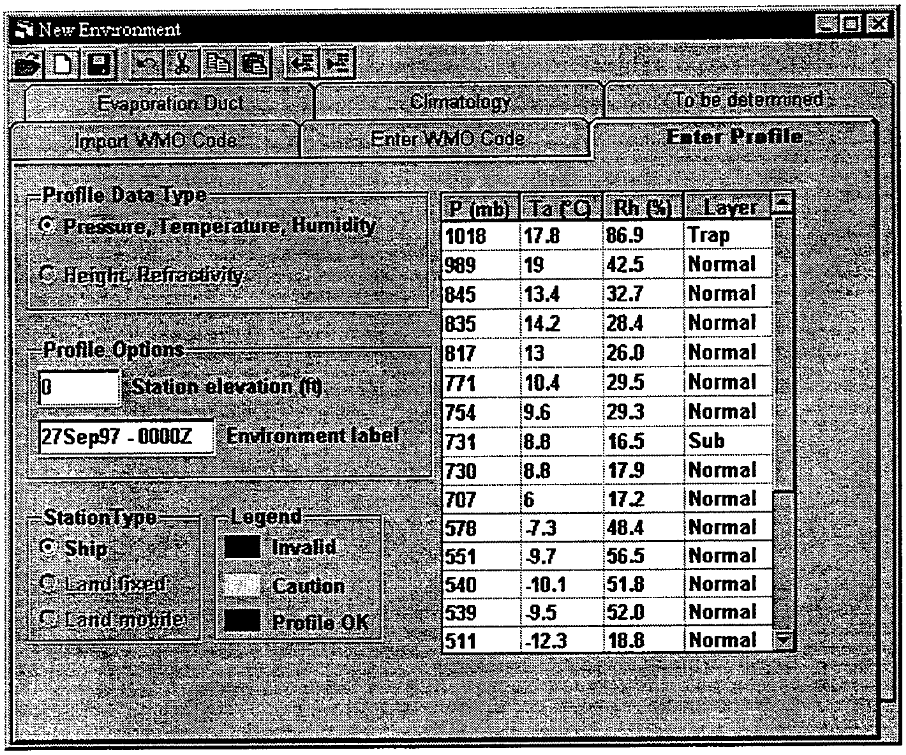


Figure 7-4: Enter Profile tab.

The insert and remove level toolbar buttons only work within this tab. Inserting a level will open a new level above the current cursor location. The level to be deleted is shown by the current cursor location. The Undo, Cut, Copy, and Paste toolbar buttons do not work within the tabular form but will work for other input fields.

By default, the profile tabular form is set to pressure, temperature, and humidity. If you have data in height and refractivity or modified refractivity, you may select the appropriate option button to change the columns on the tabular form. Once data have been entered into the form by either method, you may not change data types until you either delete all the entered levels with the remove level toolbar button, open a new environment with the New toolbar button, or save the profile and reopen the environment window.

As data are entered in the profile tabular form, the profile will be created. Once a level has sufficient data, a description of the refractive condition between that level and the previous level will be displayed in the rightmost column of the tabular form. These conditions are Sub (subrefraction), Neutral (zero M-unit gradient), Normal (normal refraction), Super (superrefraction), and Trap (trapping).

The first column of the profile tabular form contains pressure or height values depending upon the profile type selected. The pressure values must be decreasing in height. The heights must either increase or remain the same. If the two adjacent heights are equal, the corresponding N/M-unit value in column two of the tabular form must also be equal. The units of pressure may be hectoPascals, millibars, or inches of Mercury. The units of height may be feet or meters. You may change the units by right clicking on the column label.

By default, changing units will not affect the number within the input field. Thus, just changing units will give you a completely different profile. By selecting the **Convert values when units change** option (found on the **Save/Edit** tab of the **Options** menu), however, all numeric values within the column will be converted to the new units and the profile should remain the same.

When values are converted, they may be rounded and precision may be lost. Converting the value again could compound the rounding error. Therefore, converting back to the original units may not convert the value back to its original value. USE THE CONVERT UTILITY WITH CARE!

The second column of the profile tabular form contains temperature or refractivity/modified refractivity values depending upon the profile type selected. The units of temperature may be Fahrenheit, Celsius, or Kelvin. The units of refractivity may be N/M-units. Again, you may change units by right clicking on the column label.

The third column of the profile tabular form contains humidity values or a refractive summary statement depending upon the profile type selected. Humidity may be entered in three forms: relative humidity (%), dewpoint temperature (F, C, or K), or dewpoint depression temperature (F, C, or K).

Note that while all temperatures are either English (F) or metric (C or K), the concept of dewpoint depression units is different from the air or dewpoint temperature units. The dewpoint depression is the difference in degrees between the air temperature and the dewpoint. Therefore, in any dewpoint depression unit conversion between the English (F) and metric (C or F) system, the constant of 32 is not used. That is, 1 Celsius degree equals 1.8 Fahrenheit degree while 1 degree Celsius equals 33.8 degrees Fahrenheit.

Evaporation Duct Tab

You may use this tab, illustrated in figure 7-5, to create an evaporation duct profile by either entering a value for surface temperature, humidity, sea-surface temperature, and wind speed, or by entering an evaporation duct height and a stability parameter in the appropriate input fields.

If you enter a ship radiosonde from any of the three other entry tabs, a neutral profile (air and sea surface temperature are equal) evaporation duct will be automatically

calculated and merged with the upper-air data from the radiosonde. For this calculation, the surface level of the radiosonde is assumed to occur at an altitude of 6 meters (or the non-zero station elevation if entered). In either case, a surface (sea-surface) M-unit value will be calculated for the required evaporation duct height and the evaporation duct and upper-air profiles will be merged at the launch height. To prevent appending the evaporation duct profile, uncheck the option **Append duct to radiosonde** checkbox.

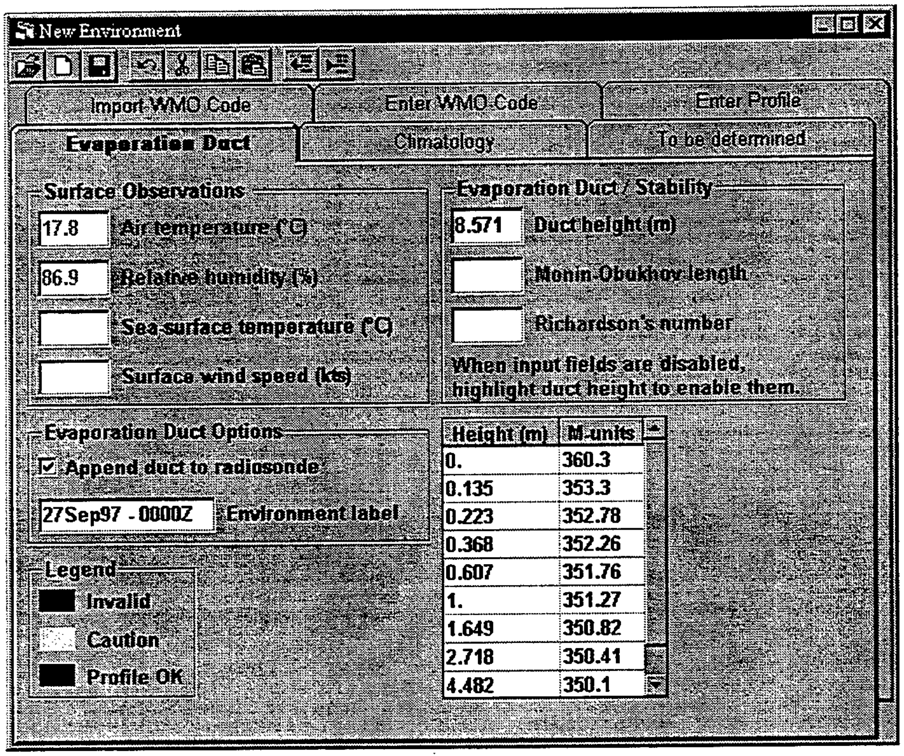


Figure 7-5: Evaporation Duct tab.

If a land station radiosonde is entered, you will have access to the Evaporation Duct tab but you will also receive a warning about appending an evaporation duct profile onto the bottom of a land station profile. We allow you this option in case the land station is along the coast and you feel its data are representative of those over the water.

Surface Observation Input Fields

Air Temperature

The surface temperature of the air is best measured with a hand-held psychrometer at any location above 6 meters (20 feet). Be careful to minimize any ship-induced effects such as heating from exhaust vents or radiating surfaces. The units may be F, C, or K.

Humidity

The surface humidity may be entered in three forms: relative humidity (%), dewpoint temperature (F, C, or K), or dewpoint depression temperature (F, C, or K). To change the humidity type and units, right click on the label. The humidity is best measured at the same location with the air temperature.

Sea Surface Temperature

The temperature at the sea surface is best measured with an accurate thermometer and a small bucket lowered into undisturbed water. Satisfactory measurements are also obtainable by using the surface temperature from an expendable bathythermograph (XBT) if the XBT is not launched into the wake.

Injection water temperature measurements are very inaccurate for the purpose here and should be avoided if another temperature source is available.

Surface Wind Speed

The true wind speed at the sea surface is best measured at the location of the air temperature and humidity measurements. The units may be knots or meter per second.

Evaporation Duct Input Fields

Evaporation Duct Height

If a profile has been previously entered from any of the other tabs (except climatology), the surface air temperature and humidity input fields will be disabled. If you have independent information saying the evaporation duct height calculated is wrong, you may correct it by one of two methods. You may return to the **Enter Profile** tab and edit the surface temperature and humidity values in the profile tabular form, or you may click on the evaporation duct height input field to enable the surface observation values. You may then enter a new temperature or humidity. Lacking a surface observation, you may enter the duct height directly along with one of the two stability parameters (Monin-Obukhov length or Richardson number).

Monin-Obukhov Length

In 1954, Monin and Obukhov proposed a boundary layer similarity theory. In this theory, a relationship between two mechanical systems exists in that a proportional alteration of units of length, mass, and time measured in one system go identically into those in the other system. In particular, this implies constant ratios of forces in the two systems. The Monin-Obukhov length is a scaling parameter applied in height calculation functions. The length depends on both the shear stress of the wind upon the surface and the heat flux between the surface (ground or water) and the air.

Richardson Number

The Richardson number is a non-dimensional number arising in the study of shearing flows of stratified fluid. In Richardson's original interpretation, this is a characteristic ratio of work done against gravitational stability to energy transferred from mean to turbulent motion.

Evaporation Duct Profile

If the environment has been entered from any of the other tabs (except climatology), this tabular form displays the merger of the evaporation duct profile and the upper-air profile. If an evaporation duct profile has been created from this tab by entering surface observations or the height and stability parameter directly, this tabular form displays only the evaporation duct profile. This tabular form is for display only. You may not edit any numbers within it.

Climatology Tab

GTE Sylvania, under contract to the Department of Defense, conducted a large-scale analysis of approximately 3 million worldwide radiosonde soundings from 921 observing stations. Numerous statistics of tropospheric ducts and super-refractive layers were compiled. Using the Climatology tab, illustrated in figure 7-6, you may construct an M-unit profile based upon the statistics of the survey.

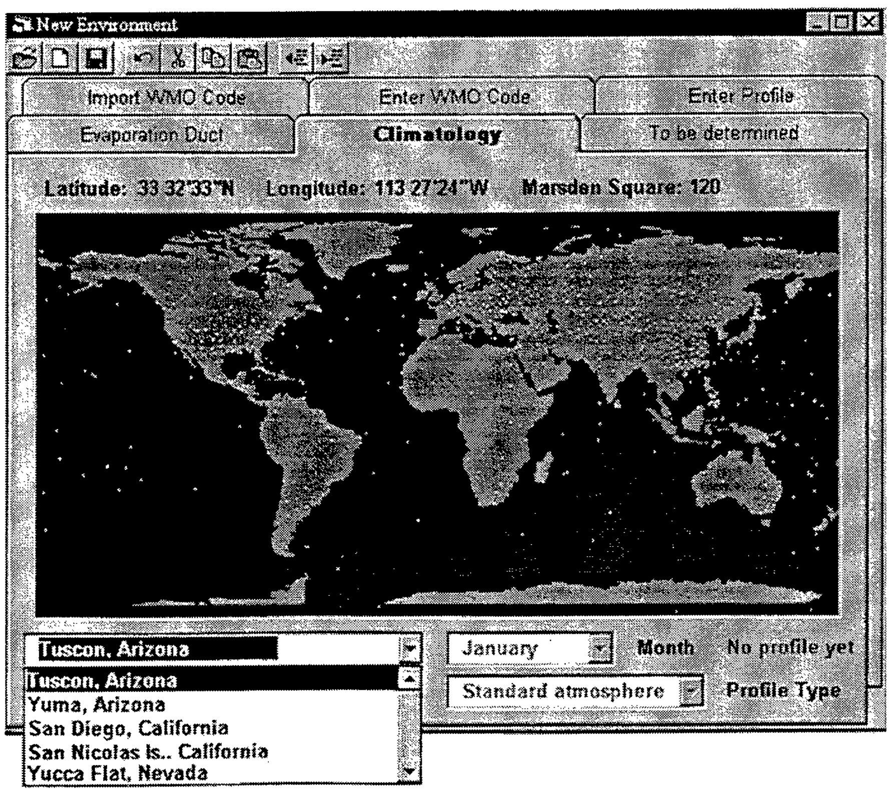


Figure 7-6: Climatology tab.

The 921 stations are shown as dots on the world map. As the mouse cursor moves about the map, its latitude, longitude, and Marsden square location are shown just above the map. Clicking on the map will fill the station name dropdown menu with the names of all the observing stations within the Marsden square.

Select a station name from the name dropdown menu, a month of interest from the month dropdown menu, and a profile type from the profile type dropdown menu. The profile types may be standard atmosphere, surface-based duct, elevated duct, and a combination of surface-based and elevated ducts. As the profiles are created, the percent occurrence of such a profile shows in the right status bar panel.

Please note the profile you select may occur only a very small percentage of the time. For these cases, you must ensure the ultimate user of the decision aid understands the likelihood of the environment.

Refractive Summary Window

The refractive summary window, illustrated in figure 7-7, shows the existing refractive conditions for the location and time of the environmental data entered. The summary shows refractivity (*N*-units) and modified refractivity (*M*-units) as a function of altitude. The presence and vertical extent of any ducts show as shaded areas on a vertical bar to the right of the refractivity profiles. The trapping layer within this shaded area is colored a deeper red to distinguish the layer from the resulting duct. The profile lines are color-coded according to the refractive conditions within each layer.

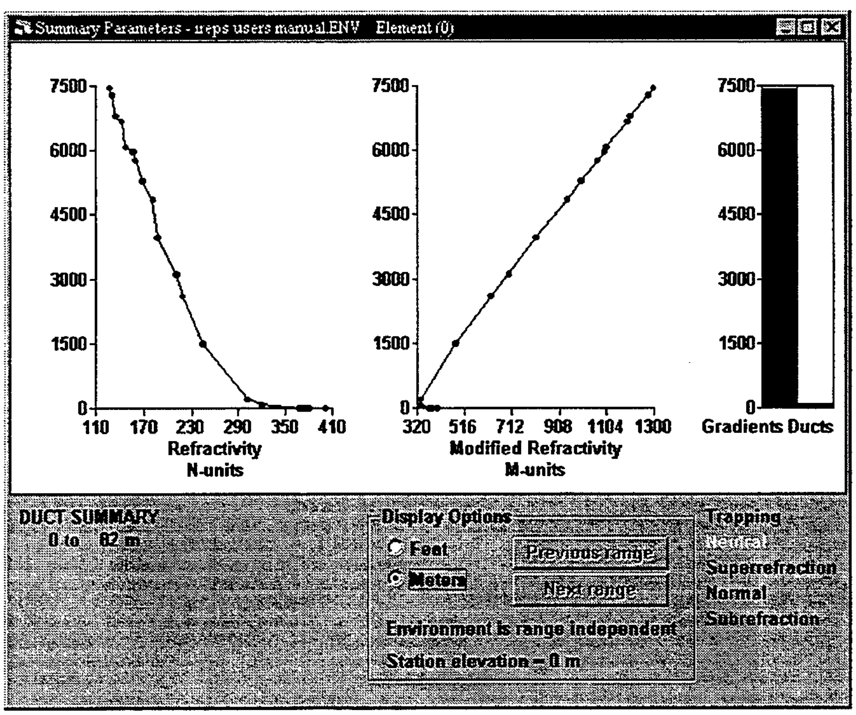


Figure 7-7: Refractive summary window.

In addition to the environmental files created with the AREPS program, this summary window will also accept files (range dependent or range independent) you may create external to AREPS, assuming the proper file conventions are followed.

You may use the refractive summary to assess the reliability of the environmental data. Rapid fluctuations in refractivity or unusually sharp gradients in refractivity, both of which may be caused by environmental input errors or improper environmental assessment methods, will become obvious by inspecting the profiles. In addition, the profiles may be inspected to ensure meteorological consistency. For example, if a Foehn condition is known to exist, there should be an indication of a surface-based duct. The evaporation duct height should be inspected. Any evaporation duct height greater than 40 meters should immediately be suspect.

World Meteorological Organization (WMO) Code

The World Meteorological Organization defines a meteorological message as a message comprising a single meteorological bulletin. AREPS uses the TEMP, TEMP SHIP, or TEMP MOBILE message formats. The message is composed of five-character figure groups divided into two parts labeled XXAA and XXBB, where XX is replaced with TT for fixed land stations, II for mobile land stations, and UU for ship stations. The XXAA section reports data for mandatory isobaric surfaces. The mandatory levels are isobaric surfaces of 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, and 100 millibars (hectopascals). Section XXBB reports data for significant levels with respect to pressure, temperature, and humidity. The AREPS program uses the XXBB portion of the WMO message.

In general, a significant level is defined as a level at which temperature and/or relative humidity data are sufficiently important, or unusual, to warrant the attention of a forecaster (such as cloud bases or icing strata) or to allow for precise plotting of the radiosonde observation. The criteria for determining significant levels for international exchange are based on the premise that significant level data alone shall make it possible to reconstruct the air temperature and relative humidity curves. These criteria are:

1. For temperature at pressures of 300 millibars or greater, the temperature between two adjacent levels should not differ more than 1 degree Celsius from that obtained by linear interpolation between the two selected levels.

2. For relative humidity at all pressures, the relative humidity between two adjacent levels should not differ more than 10 percent from that obtained by linear interpolation between the two selected levels.

3. Surface data.

4. Bases of clouds and icing strata.

5. The highest and lowest temperature on the plotted curve from the surface up to and including the terminating level.

6. The highest and lowest humidity on the plotted curve from the surface up to and including the terminating level.

7. The boundary levels of a stratum whose temperature and/or humidity is missing or doubtful.

8. The lower boundary of a stratum of more than 50 millibars in extent for which humidity is missing, provided the humidity values continue to be missing for the remainder of the ascent.

9. Termination of the ascent.

10. Whenever a series of relatively thin strata (approximately 100 meters thick) having different lapse rates occur adjacent to one another, data for only the lowermost and uppermost of such levels will be transmitted.

Five-Character Figure Groups

Station Identification Group

The WMO system of index numbers for identifying observing stations consists of two parts: a block number and a station number. When these two numbers are combined, the resulting group provides a unique number for each station. Block numbers are allocated to countries or geographic areas by the WMO. Each block number identifies 1000 station numbers assigned by the specific country. The first digit of the station number is a north/south indicator with smallest digits to the south and largest digits to the north of the block. The last two digits are an east/west indicator with the smallest digits to the east and largest digits to the west of the block. The format of the group is IIiii where:

II	=	Block number
Iii	=	Station number

Date and Time group

This group reports the date and time of the observation. The format of the group is YYGGI where:

YY	=	day of month (+50 if winds are reported in knots)
GG	=	nearest whole hour (Greenwich Mean Time)
I	=	hundreds of millibars relative to last wind surface

Latitude Group

This group reports the latitude of the observing station. The format of this figure group is 99LLL where:

99	=	indicator for sea station.
LLL	=	latitude, degrees, and tenths.

Longitude Group

This group reports the longitude of the observing station. The format of this group is QLLLL where:

Q	=	quadrant of globe. 1=NE, 3=SE, 5=SW, 7=NW. The north/south line is 0 degrees latitude and the east/west dividing line is 0 degrees longitude.
LLLL	=	longitude, degrees, and tenths

Marsden Square Group

As a way of grouping meteorological observations for climatology purposes, the entire world is divided into 10-degree by 10-degree squares called Marsden squares. A map of these Marsden squares may be found in the Surface Duct Summary program of EREPS. This WMO code group defines the Marsden square of the observing station. The format of this group is MMMUU where:

MMM	=	Marsden square number for ship location.
U	=	Units digit of latitude.
U	=	Units digit of longitude.

Station Elevation Group

For mobile land stations, the elevation of the reporting station is given together with the elevation units and the accuracy of the elevation. The format of this group is $h_o h_o h_o h_o i_m$ where:

$h_o h_o h_o h_o$	=	Station elevation
i_m	=	Units and accuracy of station elevation.

The reported units and accuracy of the station elevation are defined in the WMO code table 1845 and illustrated in table 7-2.

Table 7-2: WMO code table 1845.

Code figure	Units used	Confidence factor
1	meters	Excellent (within 3 meters)
2	meters	Good (within 10 meters)
3	meters	Fair (within 20 meters)
4	meters	Poor (more than 20 meters)
5	feet	Excellent (within 10 feet)
6	feet	Good (within 30 feet)
7	feet	Fair (within 60 feet)
8	Feet	Poor (more than 60 feet)

Significant Pressure Groups

This group reports the pressure for a significant (or surface) level. The format of this figure group is 00PPP where:

00 = indicator for surface data (99 if land station).
PPP = extrapolated surface pressure in whole millibars (hectopascals), hundreds, tens, and units, i.e., 1013.2 mb = 013 or 987.2 mb = 987.

All remaining pressure groups are significant levels. The format of these figure groups is XXPPP where:

XX = indicator for significant level. Significant levels are consecutively numbered 11, 22, 33, etc., and are repeated after 99.
PPP = pressure in whole millibars (hectopascals), hundreds, tens, and units, i.e., 1004.2 mb = 004 or 457.2 mb = 457.

When a stratum of missing data occurs and observed data are available below and above the missing stratum, a set of data is inserted to represent the missing stratum. For example, if a missing stratum occurs following the second significant level, the coding would be 33///, with the solidi (///) serving as place holders.

Significant Temperature Groups

These groups report the temperature and dewpoint depression temperature for a significant (or surface) level. The format of this figure group is TTTDD where:

TT = air temperature in whole degrees Celsius.
T = approximate tenths value, even for positive temperatures and odd for negative temperatures.
DD = depression of dewpoint temperature with respect to water.

Subtract the dewpoint depression from the air temperature to obtain the dewpoint temperature. The reported numbers are from WMO code table 102 and illustrated in table 7-3.

Table 7-3: WMO code table 102

00 = 0.0 C	50 = 5.0 C
01 = 0.1 C	51-55 are not used
02 = 0.2 C	56 = 6.0 C
...	57 = 7.0 C
...	...
...	98 = 48.0 C
49 = 4.9 C	99 = 49.0 C or more

All remaining temperature groups are associated with significant levels. The format of these figure groups is same as above. If only the dewpoint temperature depression is missing, the group is reported as TTT//, with the solidi (//) serving as placeholders. If the temperature is also missing, the group is reported as ///// with the corresponding pressure group also reported as XX///. When entering temperature groups, just enter the // for the dewpoint depression only, i.e., skip the whole level for which the pressure group is XX/// and the temperature group is /////.

Environmental File Format

AREPS is fully capable of accounting for variations in vertical refractivity data that may vary in range and bearing. The difficulty is no ready source of range and bearing dependent refractivity data exists and the normal data availability will be a single radiosonde. Should range and bearing refractivity data be available, you may construct a range dependent environmental input file based on two or more profiles using a text editor, such as Notepad. For all numerical information within the file, commas as place separators are not allowed. For example, a representation of height as "7,234.00" is not allowed. The correct representation of the height is "7234.00." Commas may, however, be used to separate columns of numbers.

Bearing Dependency

In reality, an environmental file would normally only apply to a limited sector of bearings. However, if you have bearing varying refractivity data, the environmental file may contain it and AREPS will consider it.

Radio-refractivity (Meteorological) Field Restrictions

A refractivity field is defined as a collection of M-unit versus height profiles that describe the atmosphere's refractive structure in three dimensions. ARPES places certain restrictions upon these profiles. These restrictions are:

1. A profile is defined as couplets of height (feet or meters) and refractivity (N-units) or modified refractivity (M-units). The first numbered data point within a profile must correspond to a height of zero (mean sea level), even for profiles used over terrain paths. The environment window accounts for this requirement with its station elevation input. The maximum number of couplets for AREPS is unlimited.

2. Within each profile, each numbered data point must correspond to a height greater than or equal to the previous height. If two adjacent heights are equal, the N or M-units value must also be equal.

3. For range dependent files, the field may consist of an unlimited number of vertical piece-wise linear profiles at multiple arbitrary ranges. The range to the first profile must be zero.

4. For range dependent files, each profile must contain the same number of vertical data points and be specified such that each numbered data point corresponds to like-numbered points (i.e., features) in other profiles. Therefore, you must inspect all the individual profiles and identify common features between them.

File Key Words and Symbols

The file contains a number of key words and symbols (keywords are case insensitive) which describe the data. These key words and symbols are:

– A line beginning with a # is a comment and is ignored by AREPS.

@feet or @ft – signifies all heights are in units of feet.

@meters or @m – signifies all heights are in units of meters. If the @feet is not present, meters are assumed unless specified otherwise within the @height keyword.

@height – signifies the units for all values of height. Following this keyword is the unit keyword. The unit keyword may be ft, feet, m, or meters. If the unit keyword is not present, an error will be announced. An example is @height m.

@nm, @nmi, @km, @sm, @kilometers, @nautical miles, @statute miles – signifies all ranges are in the unit of nautical miles, kilometers, or statute miles. If this keyword is not present, kilometers are assumed unless specified otherwise within the @range keyword.

@range – signifies a range from zero to the profile that follows. Following this keyword is the actual range value. Following the range value is a range unit keyword. The unit keyword may be kilometers, km, or k; nautical miles, nm, nmi, or n; statute miles, sm, or s. If the unit keyword is not present, kilometers are assumed. Some examples are @range 39 sm, @RANGE 52, and @range 100 nautical miles.

@station – signifies the elevation (above or below mean sea level) of the station making the observation. Following this keyword is the actual height value. Following the height value is a height unit keyword. The unit keyword may be meters, feet, m or ft. If the unit keyword is not present, meters are assumed. Some examples are @station 20, @station 5280 feet, @station 15 m.

@ref – signifies the type of refractivity values in the profile. Following this keyword is either an M (for M-units) or N (for N-units). If this refractivity keyword is not present, M-units are assumed.

@tair or @air – signifies the surface air temperature. Following this keyword is the actual air temperature value. Following the air temperature value is the air temperature unit keyword. The unit keyword may be f, Fahrenheit; c or Celsius; and k or Kelvin. If the unit keyword is not present, Celsius is assumed. Some examples are @tair 15.2 C and @air 32 f.

@humid – signifies a surface humidity. Following this keyword is a keyword for the type of surface humidity. The humidity type may be abs (for absolute humidity), rel (for relative humidity), dewpt (for dewpoint temperature) and dewdep (for dewpoint depression temperature). Following the humidity type keyword is the actual humidity value. Following the humidity value is the humidity value unit keyword. For absolute humidity, the units are grams per cubic meter, for relative humidity the units are percent, for dewpoint and dewpoint depression temperature, the units may be either f, Fahrenheit, c, Celsius, k, or Kelvin. If the unit keyword is not present, the dewpoint or dewpoint depression temperature units are assumed to be Celsius. Some examples are @abs 8.3; @dewpt 12.6 C; @rel 86.

@abshum – signifies a surface absolute humidity. Following the keyword is the value for surface absolute humidity. The units of absolute humidity are grams per cubic meter. The units need not be specified.

@label – signifies a label for the AREPS program.

@bearing – signifies all input values following this keyword apply to a specific bearing until another @bearing keyword is encountered. This keyword need not be used if there are data for only one bearing within the environmental file. Following the @bearing keyword is the actual bearing value. The units of bearing are degrees True. Some examples are @bearing 020, @bearing 40, @bearing 0, and @bearing 360. The bearings of 0 and 360 are assumed to be the same. If a bearing value is not present, an error will be announced. When an @bearing keyword is encountered within the

environmental files, any previous keywords will be ignored. For example, if the keyword @height feet were to precede the @bearing, it will be ignored, and if no additional height unit keyword were encountered, all heights following the @bearing keyword will be assumed to be in meters (the default units of height). For this reason, if you intend to use a bearing dependent environmental file, you should ensure the @bearing keyword appears first in the keyword order.

File Units

Units may be mixed or changed anywhere between profiles but not within any single profile. The units apply to all following data until the units are changed again or an @bearing keyword in encountered. Blank lines, spaces, data deliminators (i.e., a comma or spaces separating height from M-unit values), and any characters following the M-unit or N-unit value are ignored.

It is possible to make an error in the keyword and still have the program accept the data. Erroneous results will occur that MAY NOT BE OBVIOUS. Ensure keywords are used properly.

The following is a sample of a file that contains data for six profiles. These profiles were measured from an aircraft flying a saw-tooth pattern from San Diego, CA, to Guadelupe Isle, Mexico. Note that there is one @feet keyword, indicating that all the height values within all the profiles are feet. Note there is no @bearing keyword. This indicates a non-bearing dependent environment. If you would like to use these profiles as a demonstration of AREPS' ability to include range dependent environmental effects, they are available within the on-line help. Copy these profiles onto the clipboard and them paste them into a new text file opened with Notepad. Save the new file with a .ENV extension. Copy or move the file into AREPS' environment folder. Select this environmental file from the environment dropdown menu in the project window.

```
# range dependent environmental input data for AREPS
@label San Diego to Guadelupe Isle
@feet
@range 0 nm
0.0,        337.000    1st layer - normal gradient
540,        358.44     2nd layer - trapping gradient
803.407,    324.736    3rd layer - normal gradient
1217.17,    334.888    4th layer - trapping gradient
1231.0,     334.494    5th layer - subrefractive gradient
3500.0,     447.400

@range 39 nm
0.0,        337.000    1st layer - normal gradient
540,        358.44     2nd layer - trapping gradient
803.407,    324.736    3rd layer - normal gradient
1217.17,    334.888    4th layer - trapping gradient
```

1231.0,	334.494	5th layer - subrefractive gradient
3500.0,	447.400	

@range 85.5 nm

0.0,	337.169	1st layer - normal gradient
740,	365.34	2nd layer - trapping gradient
1080.63,	343.702	3rd layer - normal gradient
1490.61,	356.039	4th layer - trapping gradient
1652.63,	351.889	5th layer - normal gradient
3500.0,	430.919	

@range 125. nm

0.0,	335.819	1st layer - normal gradient
1190,	382.84	2nd layer - trapping gradient
1574.55,	357.962	3rd layer - normal gradient
1889.38,	371.111	4th layer - trapping gradient
2096.94,	371.011	5th layer - normal gradient
3500.0,	430.957	

@range 160. nm

0.0,	333.676	1st layer - normal gradient
1145.0,	378.220	2nd layer - trapping gradient
2140.0,	370.715	3rd layer - subrefractive gradient
2584.38,	398.294	4th layer - superrefractive gradient
2923.08,	404.423	5th layer - normal gradient
3500.0,	429.802	

@range 193. nm

0.0,	331.056	1st layer - normal gradient
1420.0,	382.920	2nd layer - superrefractive gradient
2387.5,	383.544	3rd layer - subrefractive gradient
2718.44,	410.029	4th layer - trapping layer
2892.62,	399.773	5th layer - subrefractive gradient
3500.0,	430.849	

How to Construct a Range Dependent Environmental File

Constructing a range dependent environmental input file consists of four steps. These are preparing the data, mapping the evaporation duct portion of the profiles if they exist, mapping the upper-air portion of the profiles, and merging the profiles into one file. Each of these steps involves a number of sub-steps. It is highly recommended you study the techniques of these steps and their sub-steps prior to making an operational input file. Be aware that these steps describe the technique of mapping two or more M-unit versus height profiles together. You must ensure any mapping decisions you make during these

steps are consistent with the true thermodynamical and hydrological layering of the atmosphere.

The mapping technique may be applied to as many profiles as you have, provided they are in a line of bearing and that they are mapped in order. That is, profile 1 and profile 2 are mapped, profile 3 is mapped into the combination of profile 1 and 2's mapping, and so forth in range. Prior to taking the steps, you may want to review the considerations for range dependent environments and the definitions used in this description. For bearing dependent environmental files, the procedure for each bearing is that described here. The only other requirement is to precede the mapped profiles with the @bearing keyword within the final operational input file.

▶ Step 1: Preparing the Data

Preparing the data consists of three sub-steps or operations: gathering the data, evaluating the data, and reducing the data. Each operation is described below.

Gathering the Profile Data

Prior to creating a range dependent environmental input file for AREPS, you must make a number of judgments about the profile data available. If you are able to answer yes to all the following questions, proceed with the construction. If not, you should not attempt to make a range dependent input file as erroneous displays will lead to invalid tactical decisions.

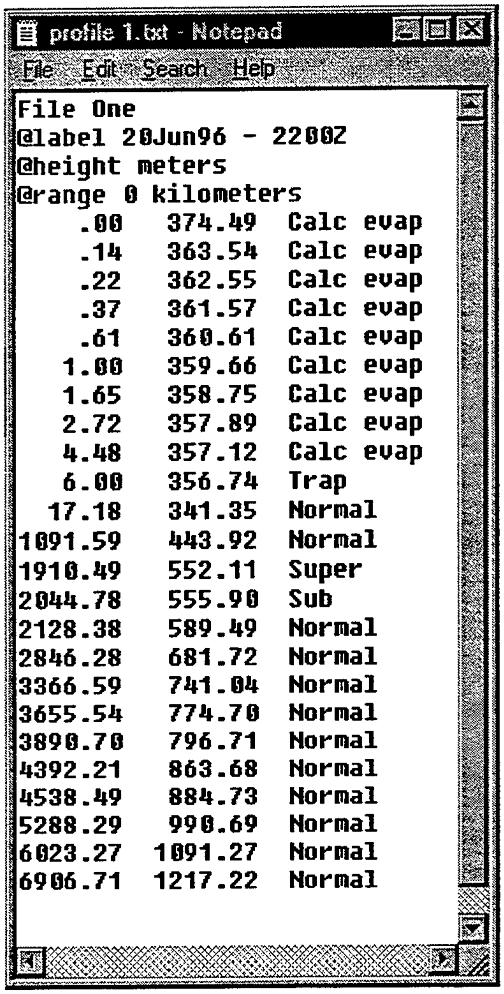
1. Are the profiles in a rough line-of-bearing toward the threat bearing?

2. Are all the profiles from the same observation period?

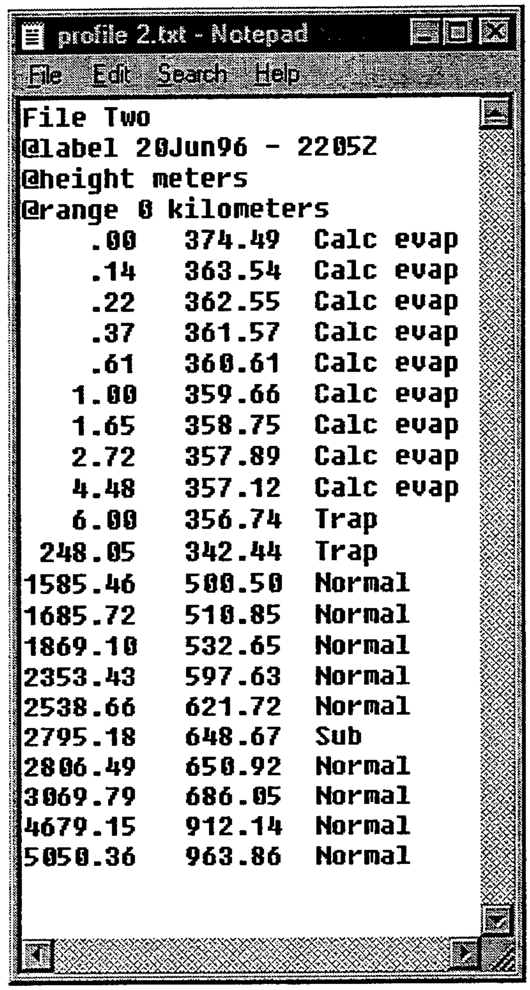
3. If the profiles are not within the same observation period, have the meteorological conditions remained sufficiently constant to warrant using persistence?

4. Are all the profiles contained within the same air mass (no fronts between the profiles)?

Once you are comfortable with the representativeness of the environmental data, start the AREPS program. Then create and save the two (or more) environmental profile files using the WMO (or other) input method. Exit (or minimize) the AREPS program and open each file using the Windows Notepad program. Delete all lines except for the height and M-unit data and lines that begin with an @ sign. Also delete the pressure, temperature, and humidity data if these data exists. Retain the refractive description information for the time being. While not a requirement, it is a good idea to print these files to paper for reference. In addition, you should produce and print a refractive summary for each file. Figure 7-8 is an example of two such processed files.




```
File One
@label 20Jun96 - 2200Z
@height meters
@range 0 kilometers
     .00    374.49  Calc evap
     .14    363.54  Calc evap
     .22    362.55  Calc evap
     .37    361.57  Calc evap
     .61    360.61  Calc evap
    1.00    359.66  Calc evap
    1.65    358.75  Calc evap
    2.72    357.89  Calc evap
    4.48    357.12  Calc evap
    6.00    356.74  Trap
   17.18    341.35  Normal
 1091.59    443.92  Normal
 1910.49    552.11  Super
 2044.78    555.90  Sub
 2128.38    589.49  Normal
 2846.28    681.72  Normal
 3366.59    741.04  Normal
 3655.54    774.70  Normal
 3890.70    796.71  Normal
 4392.21    863.68  Normal
 4538.49    884.73  Normal
 5288.29    990.69  Normal
 6023.27   1091.27  Normal
 6906.71   1217.22  Normal
```




```
File Two
@label 20Jun96 - 2205Z
@height meters
@range 0 kilometers
     .00    374.49  Calc evap
     .14    363.54  Calc evap
     .22    362.55  Calc evap
     .37    361.57  Calc evap
     .61    360.61  Calc evap
    1.00    359.66  Calc evap
    1.65    358.75  Calc evap
    2.72    357.89  Calc evap
    4.48    357.12  Calc evap
    6.00    356.74  Trap
  248.05    342.44  Trap
 1585.46    500.50  Normal
 1685.72    510.85  Normal
 1869.10    532.65  Normal
 2353.43    597.63  Normal
 2538.66    621.72  Normal
 2795.18    648.67  Sub
 2806.49    650.92  Normal
 3069.79    686.05  Normal
 4679.15    912.14  Normal
 5050.36    963.86  Normal
```

Figure 7-8: Two processed environmental files.

Evaluating the Profile Data

In using a radiosonde to measure the vertical profiles of temperature and humidity, the absolute accuracy of the data is not as important for refractivity assessment as accurate measurements of the gradients. Sensor lag tends to reduce the gradients and increase the altitude at which gradient changes occur. The lag errors are not too serious at normal radiosonde ascension rates but can be very significant at launch. Often the radiosonde is prepared in a heated or air-conditioned space and is released without allowing for the proper acclimatization of the sensors. In other cases, the radiosonde may be exposed to direct sunlight and radiating surfaces, such as being left sitting on the ship's deck for several minutes prior to launch.

Another factor that often contributes to spurious gradients is using psychrometric measurements for the surface level of the sounding. The psychrometer measurements are

more accurate than the radiosonde's. In addition, the psychrometer is not usually co-located with the radiosonde. That is, the psychrometer is carried to the best position for measurements while the radiosonde is likely to be in fixed position subject to the heat island effects of the ship.

It has been shown that within the error range of the radiosonde's sensors, an error of ±9.1 *N*-units at each reporting level may occur within conditions typical for the northern Indian Ocean. Psychrometric error may lead to ±1.3 *N*-units per observation within the same environment. Compounding this sensor error with poor acclimatization or measurement techniques could lead to extremely abnormal low-level refractive gradients in radiosonde data over the open ocean and, ultimately, to dramatic inaccuracies in the quality of the AREPS assessment products.

During the evening over land, formation of a temperature inversion in contact with the ground is common, as is an accumulation of water vapor near the surface leading to a decrease of humidity with altitude. This inversion often results in superrefractive conditions. During the daytime, a super-adiabatic layer quickly develops upward which in turn produces mechanical mixing, thereby restoring the refractive conditions back to normal. Over the open ocean there is much less variability since the sea-surface temperature may only change by a few tenths of a degree Celsius from night to day.

By plotting the values on a thermodynamic diagram such as the Department of Defense Weather Plotting Chart (DOD-WPC) 9-16-1, "USAF SKEW-T, log p Diagram," the nighttime conditions of surface temperature inversion with trapping conditions are evident. Should you receive this sounding during the daytime hours, it appears to be directly opposite to the meteorologically plausible behavior of the marine boundary layer. As the AREPS operator, you must either rationalize the refractive conditions observed with an appropriate meteorological condition or must suspect instrument error due to improper pre-launch procedures.

Even without displaying the radiosonde sounding on a thermodynamic diagram, you may also take warning by inspecting the height of the anomalous refractive condition. Characteristically, the top of the anomalous trapping, sub-refractive, or super-refractive layer is always at a pressure of 1000 millibars when the surface pressure exceeds 1000 millibars. For surface pressures less than 1000 millibars, the anomalous refractive conditions tops are at the top of the super-adiabatic layer.

AREPS does not try to correct for instrument errors. Prior to using a profile created from WMO code, you should examine the profile and correct for this anomalous condition if you feel it is erroneous. The best time to make these corrections is while you are creating the profile in the environmental window. You may do it after the fact, however, by using the following example. Table 7-4 is an example of such a profile measured from a U.S. Navy ship in the Mediterranean Sea. No evaporation duct is appended. The station elevation is 9 meters, so AREPS extrapolates a surface M-unit value based upon the M-unit gradient in the first measured layer.

Table 7-4: Mediterranean Sea observation.

@label 23Jul87 - 2300Z
@height meters
@range 0 kilometers

# Ht(m)	M-units	P (mb)	Ta (C)	Rh (%)	Layer
.0	373.8	Extrapolated			
9.0	369.7	1009.0	25.6	77.2	Trap
88.0	333.6	1000.0	25.2	44.3	Super
212.0	301.4	986.0	26.4	32.0	Normal
1502.0	480.0	850.0	19.0	10.2	Normal
2601.0	626.8	746.0	8.8	24.8	Normal
3125.0	701.0	700.0	5.8	35.7	Normal

AREPS labels the refractive layers such that the label applies to the layer above the label. That is, the trapping layer's bottom is at 9 meters (but extrapolated to the surface), and the top is at 88 meters. Likewise, the superrefractive layer's bottom is at 88 meters, and its top is at 212 meters. Based upon your expertise, you determine the 1000-millibar level superrefractive layer is in error but believe the surface trapping layer is truly present and extends from the surface to 212 meters. It is necessary, therefore, to remove the superrefractive layer. Since the *M*-unit value reaches its minimum at 212 meters, no adjustments in the profile's *M*-units values are necessary and the 9 and 88-meter levels are simply deleted.

If you determine some other condition existed, the *M*-unit values in the affected layers would have to be adjusted. For example, the surface trapping layer may also be believed not to exist. A new surface *M*-unit value is now determined by interpolation using the normal refractive gradient within the layer between 212 and 1502 meters. This extrapolated surface *M*-unit value is illustrated by the equation in figure 7-8.

$$\overset{272}{M_s} = \overset{480}{M_t} - \frac{(\overset{480}{M_t} - \overset{301}{M_b})(\overset{1502}{z_t} - \overset{0}{z_s})}{(\underset{1502}{z_t} - \underset{212}{z_b})}$$

Figure 7-8: *M*-unit extrapolation.

where M_s is the desired *M*-unit value at the surface, M_t is the *M*-unit value at the top of the normal layer, M_b is the *M*-unit value at the bottom of the normal layer, z_s is the desired surface height, z_t is the normal layer's top height, and z_b is the normal layer's

bottom height. The two resultant profiles for these considered scenarios are illustrated in table 7-5.

Table 7-5: Two possible *M*-unit extrapolation results.

Case 1: Trapping Layer Realistic	Case 2: Trapping Layer Not Realistic
@label 23Jul87 - 2300Z @height meters @range 0 kilometers .0 373.8 Extrapolated 212.0 301.4 Trap 1502.0 480.0 Normal 2601.0 626.8 Normal 3125.0 701.0 Normal	@label 23Jul87 - 2300Z @height meters @range 0 kilometers .0 272.0 Extrapolated 1502.0 480.0 Normal 2601.0 626.8 Normal 3125.0 701.0 Normal

In addition to instrument errors, a number of other errors may arise from the use of WMO code. Prior to the use of any WMO data within AREPS, it is highly recommended the data are examined with the summary display and the results evaluated for meteorological consistency and accuracy.

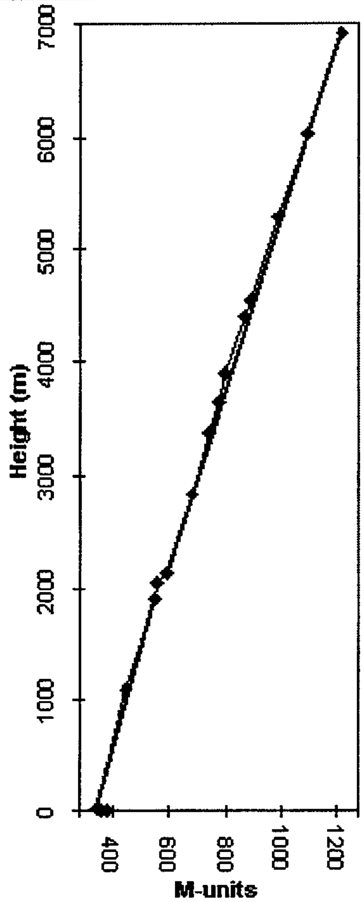
Reducing the Profile Data

Sometimes it is desirable to reduce the number of profile levels prior to starting the level mapping. You have heard the old adage that "more is better." In modified refractive profiles, this may not always be true. Reducing the number of levels within a profile is done for a number of reasons. Among these are to reduce the number of possible sensor errors, to decrease the run time of the propagation model, and to make the mapping process easier.

To examine the data for possible level reduction, produce the summary height versus *M*-unit display. Looking at the refractive condition labels within the profile, lay a straight edge along the points labeled as "Normal." If you can draw a straight line between levels such that a level is only a few *M*-units displaced from the line, you may remove the level and only keep the levels at the line's endpoints. A graphical example of reducing the number of profile levels is shown in table 7-6.

Table 7-6: Profile data reduction example.

<table>
<tr><th>File 1 - Before level Reduction</th><th>Blue Line Profile
Red Line Straight Edge</th><th>File 1 - After Level Reduction</th></tr>
<tr>
<td>@label 20Jun96 - 2200Z
@height meters
@range 0 kilometers

.00 374.49
.14 363.54
.22 362.55
.37 361.57
.61 360.61
1.00 359.66
1.65 358.75
2.72 357.89
4.48 357.12
6.00 356.74 Trap
17.18 341.35 Normal
1091.59 443.92 Normal
1910.49 552.11 Super
2044.78 555.90 Sub
2128.38 589.49 Normal
2846.28 681.72 Normal
3366.59 741.04 Normal
3655.54 774.70 Normal
3890.70 796.71 Normal
4392.21 863.68 Normal
4538.49 884.73 Normal
5288.29 990.69 Normal
6023.27 1091.27 Normal
6906.71 1217.22 Normal</td>
<td>
</td>
<td>@label 20Jun96 - 2200Z
@height meters
@range 0 kilometers

.00 374.49
.14 363.54
.22 362.55
.37 361.57
.61 360.61
1.00 359.66
1.65 358.75
2.72 357.89
4.48 357.12
6.00 356.74 Trap
17.18 341.35 Normal
1910.49 552.11 Super
2044.78 555.90 Sub
2128.38 589.49 Normal
6906.71 1217.22 Normal</td>
</tr>
</table>

For radar frequencies below about 3000 MHz, the evaporation duct has little effect. For this case, you may want to just ignore the evaporation duct portion of the profile. This will make the mapping of profiles much easier since it reduces the number of levels that need to be mapped and also avoids some of the assumptions that need to be made about how the evaporation duct varies in range. After this step has been taken, you will treat the profile as an upper-air mapping case.

⚠ Remembering that radiosonde conditions may lead to inaccuracies, prior to adjusting any *M*-unit values within the profile, you should have already evaluated the representativeness of the gradients for realistic meteorological conditions.

When AREPS appends an evaporation duct to the profile, each level within the appended portion contains the "Calculated evap..." comment. This is true even if the levels are higher in elevation than the actual evaporation duct height itself.

Prior to deleting any levels, you must first evaluate the levels to determine how you will proceed. There are two cases to consider depending on the station elevation: (a) the station elevation is zero, and (b), the station elevation is not zero. To determine which case to take, examine the height of the first non-evaporation duct level. If the station elevation was zero, AREPS makes an assumption that the station elevation is at 6 meters when appending the evaporation duct, and you should take case a. If however, the height of the first level is not 6 meters, then you should take case b.

Case a: Station elevation is 0 meters.

For this case, you simply need to delete the evaporation duct levels inserted by AREPS and replace the height of 6 meters with a height of 0 meters, keeping the *M*-unit values unchanged as illustrated in table 7-7.

Table 7-7: Two profiles – before and after evaporation duct removal.

Before Evaporation Duct Removal			After Evaporation Duct Removal		
@label 20Jun96 - 2200Z			@label 20Jun96 – 2200Z		
@height meters			@height meters		
@range 0 kilometers			@range 0 kilometers		
.00	374.49	Calculated evap	0.00	356.74	Trap
.14	363.54	Calculated evap	17.18	341.35	Normal
.22	362.55	Calculated evap	1910.49	552.11	Super
.37	361.57	Calculated evap	2044.78	555.90	Sub
.61	360.61	Calculated evap	2128.38	589.49	Normal
1.00	359.66	Calculated evap	6906.71	1217.22	Normal
1.65	358.75	Calculated evap			
2.72	357.89	Calculated evap			
4.48	357.12	Calculated evap			
6.00	356.74	Trap			
17.18	341.35	Normal			
1091.59	443.92	Normal			
1910.49	552.11	Super			
2044.78	555.90	Sub			
2128.38	589.49	Normal			
2846.28	681.72	Normal			
3366.59	741.04	Normal			
3655.54	774.70	Normal			
3890.70	796.71	Normal			

Table 7-7 (cont): Two profiles – before and after evaporation duct removal.

Before Evaporation Duct Removal			After Evaporation Duct Removal
4392.21	863.68	Normal	
4538.49	884.73	Normal	
5288.29	990.69	Normal	
6023.27	1091.27	Normal	
6906.71	1217.22	Normal	

Case b: Station elevation is not zero.

For this case, we must insert a 0 height level and extrapolate a surface *M*-unit value. The station elevation for this example is 55 feet. Surface conditions are such that a 15.34-meter evaporation duct is formed. Remember, the evaporation duct height may be found by looking for the level with the minimum M-unit value among the levels with the "Calculated evap…" comment. The first level above the evaporation duct shows a trapping condition. We've determined from evaluating the profile that a surface-based ducting condition exists so this trapping condition is representative of the true meteorological conditions. Therefore, we will use the trapping gradient between 17.00 meters and 33.94 meters to extrapolate a surface M-unit value. This is illustrated by the equation in figure 7-9.

$$\underset{374.44}{M_s} = \underset{344.35}{M_t} - \frac{(\overset{344.35}{M_t} - \overset{359.37}{M_b})(\overset{33.94}{z_t} - \overset{0.0}{z_s})}{(\underset{33.94}{z_t} - \underset{17.0}{z_b})}$$

Figure 7-9: *M*-unit extrapolation.

where M_s is the desired *M*-unit value at the surface, M_t is the *M*-unit value at the top of the trapping layer, M_b is the *M*-unit value at the bottom of the trapping layer, z_s is the desired surface height, z_t is the trapping layer's top height, and z_b is the trapping layer's bottom height. Deleting all the evaporation duct levels and inserting the extrapolated surface value now produces the profile illustrated in table 7-8.

Table 7-8: Two profiles – before and after evaporation duct removal.

Before Evaporation Duct Removal	After Evaporation Duct Removal
@label 18Jul96 - 2200Z	@label 18Jul96 - 2200Z
@height meters	@height meters
@range 0 kilometers	@range 0 kilometers
.00 374.49 Calculated evap	.00 374.44 Extrapolated

Table 7-8 (Cont): Two profiles – before and after evaporation duct removal.

Before Evaporation Duct Removal			After Evaporation Duct Removal		
.14	366.81	Calculated evap	17.00	359.37	Trap
.22	365.83	Calculated evap	33.94	344.35	Normal
.37	364.85	Calculated evap	1108.35	446.56	Normal
.61	363.89	Calculated evap	1927.25	554.75	Super
1.00	362.94	Calculated evap	2061.55	558.53	Sub
1.65	362.03	Calculated evap	2145.14	592.12	Normal
2.72	361.17	Calculated evap	2863.04	684.35	Normal
4.48	360.40	Calculated evap	3383.36	743.67	Normal
7.39	359.78	Calculated evap	3672.30	777.33	Normal
12.18	359.41	Calculated evap	3907.47	799.34	Normal
15.34	359.36	Calculated evap			
17.00	359.37	Trap			
33.94	344.35	Normal			
1108.35	446.56	Normal			
1927.25	554.75	Super			
2061.55	558.53	Sub			
2145.14	592.12	Normal			
2863.04	684.35	Normal			
3383.36	743.67	Normal			
3672.30	777.33	Normal			
3907.47	799.34	Normal			

For the remainder of the examples, we will use the non-reduced profiles so you may better see the mapping technique.

▶ Step 2: Mapping the Evaporation Duct Portion of the Profile (if an evaporation duct exists)

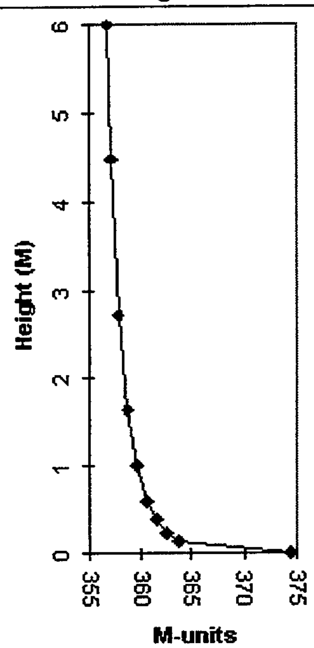
Mapping the evaporation duct consists of four cases, depending upon the relationship between land and sea sounding and station elevation. These four cases are described below.

Case a: Both profiles are over water and the station elevations are both zero.

The profiles will have the same number of points up to a height of 6 meters. For this discussion, the profile with data closest to your location is referred to as the number 1 file. The profile with data furthest from your location is referred to as the number 2 file. The file created as the result of this case is referred to as the number 3 file. The two profiles obtained during step one are used for illustration purposes.

Copy the levels (from 0 to 6 meters) from file 1 onto the clipboard and paste them into a new file (number 3) opened with Notepad. Copy the same levels from file 2 onto the clipboard and paste them into file 3, keeping a few blank lines between them and the lines from the first paste. Table 7-9 shows a graphic of the M-unit profile, the levels of files 1 and 2, and the resultant file 3.

Table 7-9: Equal evaporation duct profiles merged in one file.

M-unit / Height Profile	File 1 - Evap Duct	File 2 - Evap Duct	File 3 - Merged
	.00 374.49	.00 374.49	.00 374.49
	.14 363.54	.14 363.54	.14 363.54
	.22 362.55	.22 362.55	.22 362.55
	.37 361.57	.37 361.57	.37 361.57
	.61 360.61	.61 360.61	.61 360.61
	1.00 359.66	1.00 359.66	1.00 359.66
	1.65 358.75	1.65 358.75	1.65 358.75
	2.72 357.89	2.72 357.89	2.72 357.89
	4.48 357.12	4.48 357.12	4.48 357.12
	6.00 356.74	6.00 356.74	6.00 356.74
			.00 374.49
			.14 363.54
			.22 362.55
			.37 361.57
			.61 360.61
			1.00 359.66
			1.65 358.75
			2.72 357.89
			4.48 357.12
			6.00 356.74

Case b: Both profiles are over water and one of the station elevations is not zero.

Assume for this example, that the first profile (file 1 in case **a** above) has a station elevation of 0 meters. Assume our second profile (file 2) is taken from a radiosonde sounding with a station elevation of 10 meters. These two files are given in table 7-10.

Table 7-10: Two evaporation duct profiles from stations with differing elevations.

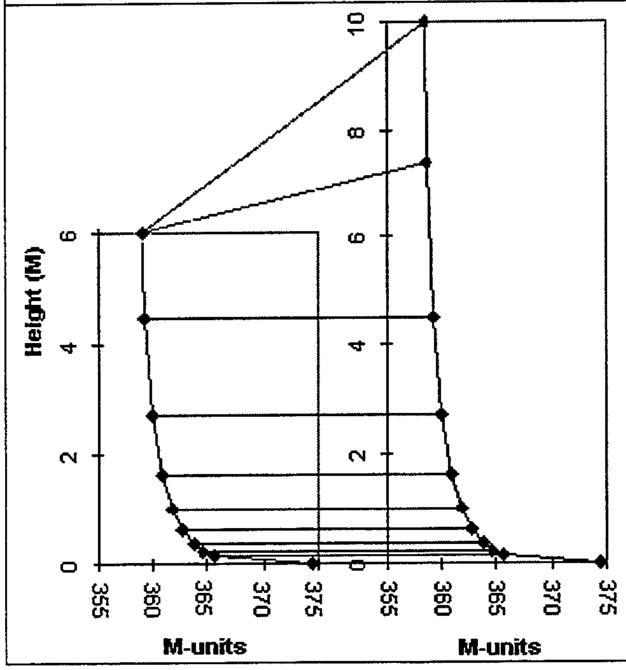
File 1 - Evap Duct Portion 0-meter station elevation			File 2 - Evap Duct Portion 10-meter station elevation		
.00	374.49	Calculated evap	.00	374.49	Calculated evap
.14	363.54	Calculated evap	.14	365.60	Calculated evap
.22	362.55	Calculated evap	.22	364.62	Calculated evap
.37	361.57	Calculated evap	.37	363.64	Calculated evap
.61	360.61	Calculated evap	.61	362.68	Calculated evap
1.00	359.66	Calculated evap	1.00	361.73	Calculated evap
1.65	358.75	Calculated evap	1.65	360.82	Calculated evap
2.72	357.89	Calculated evap	2.72	359.96	Calculated evap
4.48	357.12	Calculated evap	4.48	359.19	Calculated evap
6.00	356.74	Trap	7.39	358.57	Calculated evap
			10.00	358.31	Trap

The second profile contains 11 levels while the first contains only 10. Remembering that each profile must contain the same number of levels; it's necessary to add one level to the first profile. We must also remember that similar features from one profile must map to a similar feature on the other profile. Since the important feature here is the top of the evaporation duct, we want to keep the evaporation duct tops matched between profiles (that is, profile 1's 6-meter level will map to profile 2's 10-meter level). Thus, we need to insert a level (less than or equal to 6 meters) into profile 1, which will map to the 7.39-meter level in profile 2. The easiest way to do this is to assume that the 7.39-meter level will also map to 6-meter level of profile 1.

In file 1, insert a line just prior to the 6-meter level that will map to the 7.39-meter level of file 2. Since AREPS allows for two levels having the same *M*-unit value and we are mapping to the 6-meter level, use the 6-meter *M*-unit value for the inserted level. Table 7-10 illustrates the mapping graphically and also shows the new levels within file 1. The inserted level is so labeled.

Table 7-10: Mapping of two evaporation duct profiles.

Graphical Mapping of Two Evaporation Duct Profiles (File 1 and 2)



File 1 – result of the mapping		
.00	374.49	Calculated evap
.14	363.54	Calculated evap
.22	362.55	Calculated evap
.37	361.57	Calculated evap
.61	360.61	Calculated evap
1.00	359.66	Calculated evap
1.65	358.75	Calculated evap
2.72	357.89	Calculated evap
4.48	357.12	Calculated evap
6.00	356.74	Inserted
6.00	356.74	Trap

Combining files 1 and 2 together using the techniques of case a gives the results as shown in table 7-12.

Table 7-12: Equal evaporation duct profiles merged in one file.

File 1 - Evap Duct		File 2 - Evap Duct		File 3 - Merged	
.00	374.49	.00	374.49	.00	374.49
.14	363.54	.14	365.60	.14	363.54
.22	362.55	.22	364.62	.22	362.55
.37	361.57	.37	363.64	.37	361.57
.61	360.61	.61	362.68	.61	360.61
1.00	359.66	1.00	361.73	1.00	359.66
1.65	358.75	1.65	360.82	1.65	358.75
2.72	357.89	2.72	359.96	2.72	357.89
4.48	357.12	4.48	359.19	4.48	357.12
6.00	356.74	7.39	358.57	6.00	356.74
6.00	356.74	10.00	358.31	6.00	356.74
				.00	374.49
				.14	365.60
				.22	364.62
				.37	363.64
				.61	362.68

Table 7-12 (Cont): Equal evaporation duct profiles merged in one file.

File 1 - Evap Duct	File 2 - Evap Duct	File 3 - Merged
		1.00 361.73
		1.65 360.82
		2.72 359.96
		4.48 359.19
		7.39 358.57
		10.00 358.31

Case c: Both profiles are over water and neither of the station elevations is zero.

For this example, the first profile is created from an ocean station radiosonde with a station elevation of 40 meters. The surface conditions were such that a 15.34-meter evaporation duct height was calculated. The second profile was from an ocean station radiosonde with a station elevation of 55 meters. The surface conditions were such that a 20.99-meter evaporation duct was calculated. These two profiles are shown in the table 7-13. Remember, to determine the evaporation duct height within a profile, look for the minimum M-unit value among the levels which have the "Calculated evap…" comment. As a visualization aid, the two evaporation duct heights have been underlined in the table.

Table 7-13: Two evaporation duct profiles from stations with nonzero station elevations.

Profile 1 – Evap Duct Portion			Profile 2 – Evap Duct Portion		
.00	374.49	Calculated evap	.00	374.49	Calculated evap
.14	369.18	Calculated evap	.14	366.87	Calculated evap
.22	368.19	Calculated evap	.22	365.52	Calculated evap
.37	367.22	Calculated evap	.37	364.17	Calculated evap
.61	366.25	Calculated evap	.61	362.84	Calculated evap
1.00	365.30	Calculated evap	1.00	361.53	Calculated evap
1.65	364.39	Calculated evap	1.65	360.25	Calculated evap
2.72	363.53	Calculated evap	2.72	359.02	Calculated evap
4.48	362.76	Calculated evap	4.48	357.89	Calculated evap
7.39	362.15	Calculated evap	7.39	356.90	Calculated evap
12.18	361.77	Calculated evap	12.18	356.16	Calculated evap
<u>15.34</u>	<u>361.72</u>	<u>Calculated evap</u>	20.09	355.82	Calculated evap
20.09	361.80	Calculated evap	<u>20.99</u>	<u>355.81</u>	<u>Calculated evap</u>
33.12	362.50	Calculated evap	33.12	356.15	Calculated evap
40.00	363.02	Normal	54.60	357.58	Calculated evap
			55.00	357.61	Normal

Since the important feature is the top of the evaporation duct, we want to keep the evaporation ducts' tops matched between profiles (that is, profile 1's 15.34-meter level will map to profile 2's 20.99-meter level). In addition, note the second profile contains 13 levels up to and including the evaporation duct height, while the first profile contains only 12. Remembering that each profile must contain the same number of levels, it will be necessary to add one level to the first profile. Thus we need to insert a level (less than or equal to 15.34 meters) into the profile 1 that will map to the extra level in profile 2. The easiest way to do this is to assume that the evaporation duct height for profile 1 will also map to the extra level in profile 2. Figure 7-10 is a graphical display of this mapping and table 7-14 presents the resultant profiles. Note that two levels may have the same height as long as they also have the same M-unit value. In the figure, don't be confused with the different height scales. The important idea is to match level numbers.

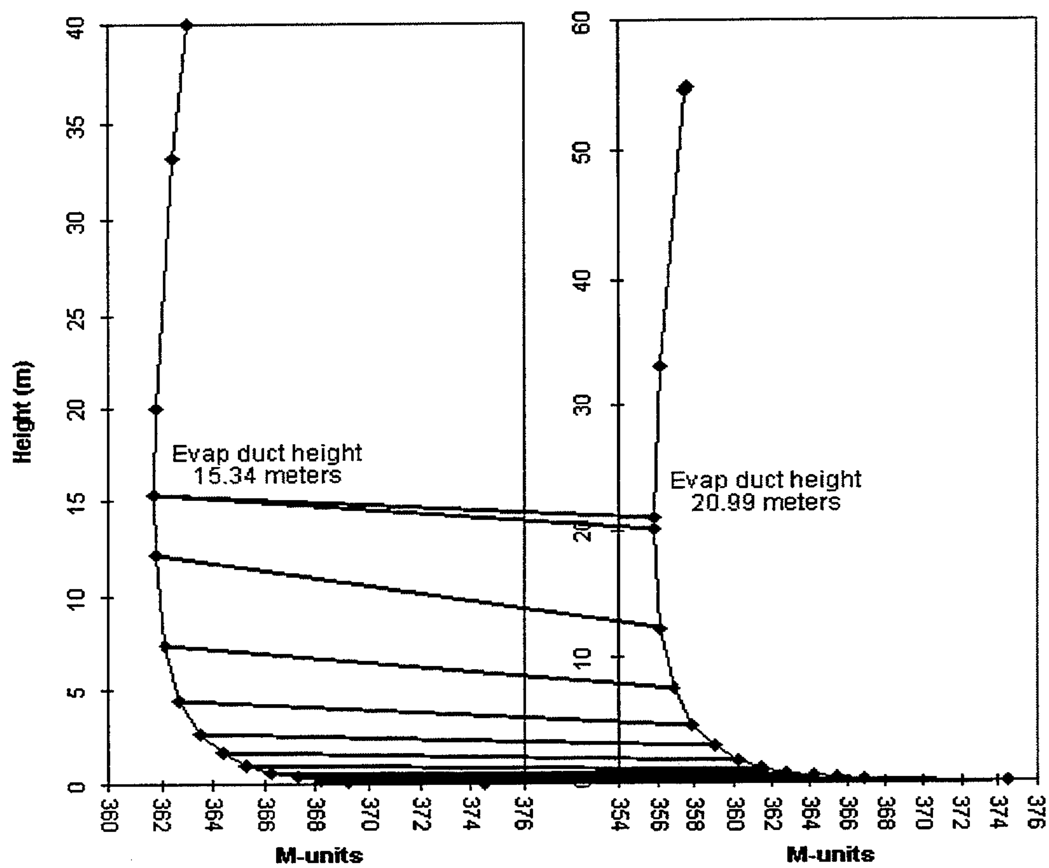


Figure 7-10: Graphical mapping of two evaporation duct profiles.

Table 7-14: Mapped evaporation duct profiles from stations with nonzero elevations.

Profile 1 – Mapped			Profile 2		
.00	374.49	Calculated evap	.00	374.49	Calculated evap
.14	369.18	Calculated evap	.14	366.87	Calculated evap
.22	368.19	Calculated evap	.22	365.52	Calculated evap
.37	367.22	Calculated evap	.37	364.17	Calculated evap
.61	366.25	Calculated evap	.61	362.84	Calculated evap
1.00	365.30	Calculated evap	1.00	361.53	Calculated evap
1.65	364.39	Calculated evap	1.65	360.25	Calculated evap
2.72	363.53	Calculated evap	2.72	359.02	Calculated evap
4.48	362.76	Calculated evap	4.48	357.89	Calculated evap
7.39	362.15	Calculated evap	7.39	356.90	Calculated evap
12.18	361.77	Calculated evap	12.18	356.16	Calculated evap
15.34	361.72	Inserted	20.09	355.82	Calculated evap
15.34	361.72	Calculated evap	20.99	355.81	Calculated evap

Case d: One profile is over water and the other is over land (no evaporation duct).

For this example, the first profile will be the same used in case **c**. The surface conditions were such that a 15.34-meter evaporation duct height was calculated. The second profile is from a land station radiosonde with no evaporation duct. For the ocean/land case, the station elevations are immaterial as AREPS starts each profile at a height of zero no matter the station elevation. These two profiles are shown in the table 7-15.

Table 7-15: Evaporation duct and land station profiles.

Profile 1 – Evap Duct Portion			Profile 2 – Land Station		
.00	374.49	Calculated evap	.00	363.02	Normal
.14	369.18	Calculated evap	40.00	374.49	Normal
.22	368.19	Calculated evap			
.37	367.22	Calculated evap			
.61	366.25	Calculated evap			
1.00	365.30	Calculated evap			
1.65	364.39	Calculated evap			
2.72	363.53	Calculated evap			
4.48	362.76	Calculated evap			
7.39	362.15	Calculated evap			
12.18	361.77	Calculated evap			
15.34	361.72	Calculated evap			
20.09	361.80	Calculated evap			
33.12	362.50	Calculated evap			
40.00	363.02	Normal			

Keeping in mind the need to map features between profiles, we must map the top of the evaporation duct in profile 1 to some feature in profile 2. The most logical mapping is to connect the evaporation duct height to the ground (level one of the land profile). For this case however, one more consideration should be made – how far away from the coast are the two profiles? If the land station is located within a few hundred meters from the water's edge, we may want to assume the evaporation duct height will map directly to the ground level.

If, however, the land station is many kilometers inland, this assumption is not desirable. For the far inland situation, it will be necessary to reproduce the ocean profile and the land profile, placing the duplicate ocean profile at a range a few hundred meters offshore and the duplicate land profile at a range corresponding to the beach. We will ultimately produce 4 profile range dependent file. (Placing of profiles at various ranges is described in step 4 of the mapping procedure). The levels from profile 1 to its duplicate at the beach (profile 2) would map directly. The levels from the duplicate land profile (profile3) to the inland profile (profile 4) would map directly, and the levels between the duplicates (profile 2 and 3) would map as shown in figure 7-11.

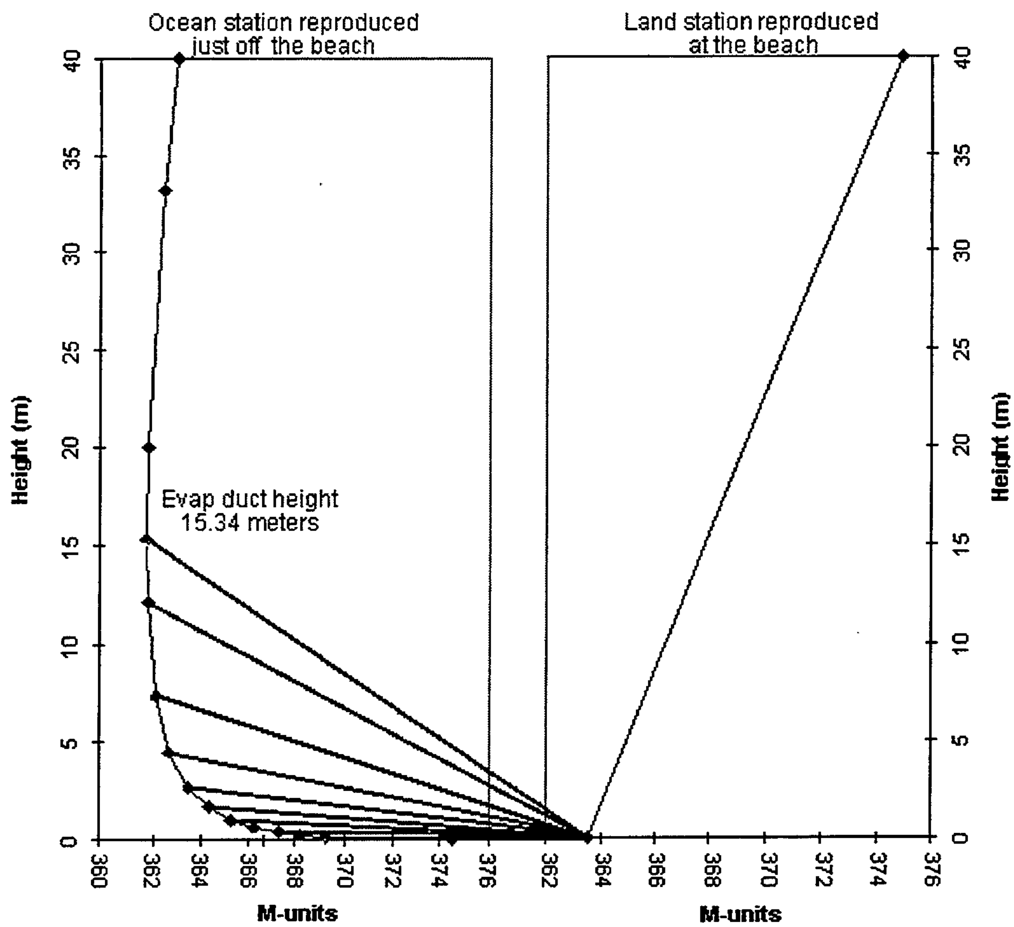


Figure 7-11: Ocean and land station graphical mapping.

Keeping with the requirement for each profile to contain the same number of levels, the land profiles (both the land profile and its duplicate) must have levels inserted using the same convention as the other evaporation duct cases. The four profiles would now appear as listed in table 7-16.

Table 7-16: Mapped evaporation duct profile to land profile.

Ocean Profile		Duplicate ocean profile just off the beach		Duplicate land profile at the beach		Land Profile	
.14	369.18	.14	369.18	.00	363.02	.00	363.02
.22	368.19	.22	368.19	.00	363.02	.00	363.02
.37	367.22	.37	367.22	.00	363.02	.00	363.02
.61	366.25	.61	366.25	.00	363.02	.00	363.02
1.00	365.30	1.00	365.30	.00	363.02	.00	363.02
1.65	364.39	1.65	364.39	.00	363.02	.00	363.02
2.72	363.53	2.72	363.53	.00	363.02	.00	363.02
4.48	362.76	4.48	362.76	.00	363.02	.00	363.02
7.39	362.15	7.39	362.15	.00	363.02	.00	363.02
12.18	361.77	12.18	361.77	.00	363.02	.00	363.02
15.34	361.72	15.34	361.72	.00	363.02	.00	363.02

▶ Step 3: Mapping the Upper-air Portion of the Profile

For this step, we must consider two possible cases. In case a, is at least one profile is over water with an evaporation duct. In case b, there is no evaporation duct or the evaporation duct was previously mapped using the techniques of step 2.

Case a: One profile is over water with an evaporation duct.

Prior to taking this step, it's assumed you have mapped the profiles should one or both contain an evaporation duct. If you haven't, please complete step 2. For the examples of upper-air cases a and b, we will assume level one of each profile is either a zero height or is the first level above the evaporation duct height.

As our first profile, we will use the one used in case d for the evaporation duct, that is, one created from an ocean station radiosonde with a station elevation of 40 meters. The surface conditions were such that a 15.34-meter evaporation duct height was calculated. The second profile is from a land station radiosonde with no evaporation duct. For the ocean/land case, the station elevations are immaterial as AREPS starts each profile at a height of zero no matter the station elevation. These two profiles are given in the table 7-17. The evaporation duct level is underlined for reference.

Table 7-17: Ocean and land station M-unit profiles.

Profile 1 – Ocean Station			Profile 2 – Land Station		
.00	374.49	Calculated evap	.00	374.49	Normal
.14	369.18	Calculated evap	40.00	363.02	Normal
.22	368.19	Calculated evap			
.37	367.22	Calculated evap			
.61	366.25	Calculated evap			
1.00	365.30	Calculated evap			
1.65	364.39	Calculated evap			
2.72	363.53	Calculated evap			
4.48	362.76	Calculated evap			
7.39	362.15	Calculated evap			
12.18	361.77	Calculated evap			
15.34	361.72	Calculated evap			
20.09	361.80	Calculated evap			
33.12	362.50	Calculated evap			
40.00	363.02	Normal			

Having previously mapped the evaporation duct portion of the ocean profile, we now turn our attention to the portion of the profile above the evaporation duct height. The 40-meter level in each profile should be mapped together. What remains to be done is to insert levels that will map to the ocean profile's 20.09-meter and 33.12-meter levels into the land profile. The easiest way to do this is to assume the inserted level heights are the same. Using the interpolation equation shown in figure 7-12, we can calculate the needed M-unit values.

$$\underset{368.73}{M_w} = \underset{374.49}{M_b} + \frac{\left(\underset{363.02}{M_a} - \underset{374.49}{M_b}\right)\left(\underset{20.09}{H_w} - \underset{0.00}{H_b}\right)}{\left(\underset{40.00}{H_a} - \underset{0.00}{H_b}\right)}$$

Figure 7-12: M-unit interpolation.

Here M_w is the *M*-unit wanted, M_a is the *M*-unit above the inserted level, M_b is the *M*-unit below the inserted level, H_w is the height of the inserted level, H_a is the height above the inserted level, and H_b is the height below the inserted level.

Similarly, we interpolate for an *M*-unit value at a height of 33.12 meters. Inserting these two levels into the land profile produces the mapped profiles given in table 7-18.

Table 7-18: Mapped ocean station evaporation duct and upper-air profile to land station.

Ocean profile		Duplicate Ocean Profile Just Off the Beach		Duplicate Land Profile at the Beach		Land profile	
.14	369.18	.14	369.18	.00	363.02	.00	363.02
.22	368.19	.22	368.19	.00	363.02	.00	363.02
.37	367.22	.37	367.22	.00	363.02	.00	363.02
.61	366.25	.61	366.25	.00	363.02	.00	363.02
1.00	365.30	1.00	365.30	.00	363.02	.00	363.02
1.65	364.39	1.65	364.39	.00	363.02	.00	363.02
2.72	363.53	2.72	363.53	.00	363.02	.00	363.02
4.48	362.76	4.48	362.76	.00	363.02	.00	363.02
7.39	362.15	7.39	362.15	.00	363.02	.00	363.02
12.18	361.77	12.18	361.77	.00	363.02	.00	363.02
15.34	361.72	15.34	361.72	.00	363.02	.00	363.02
20.09	361.80	20.09	361.80	20.09	368.73	20.09	368.73
33.12	362.50	33.12	362.50	33.12	364.99	33.12	364.99
40.00	363.02	40.00	363.02	40.00	374.49	40.00	374.49

Graphically, the mapped levels now appear as shown in figure 7-13.

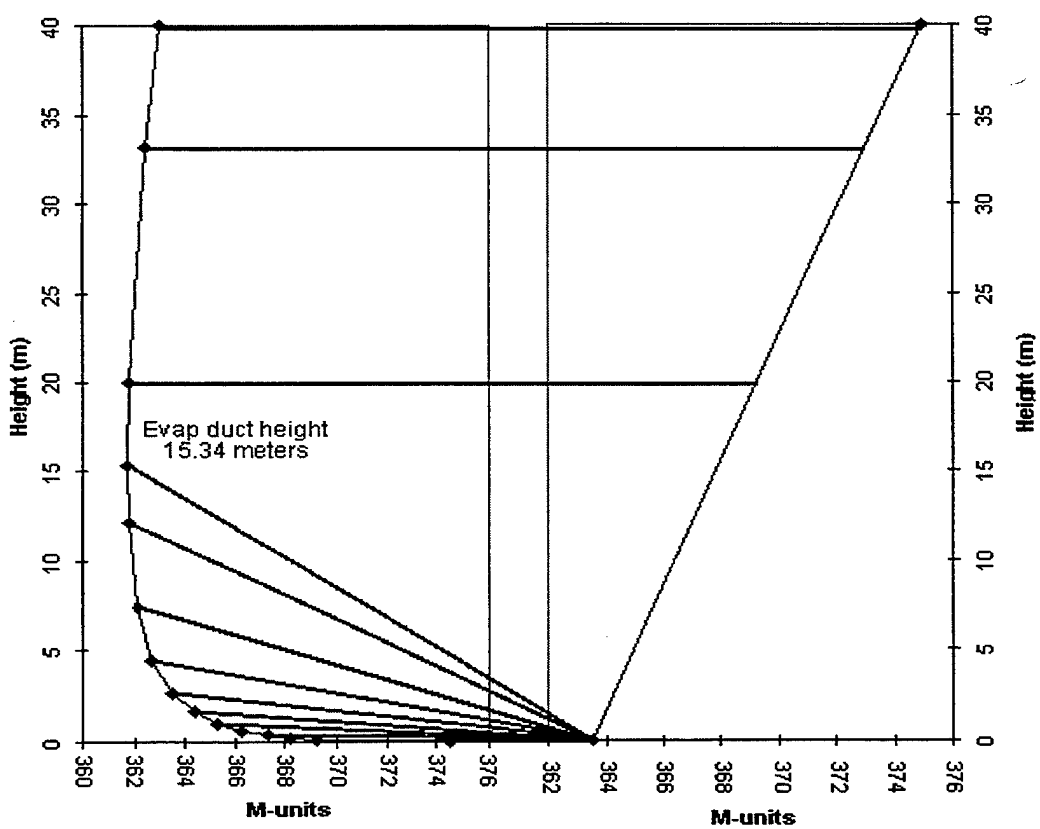


Figure 7-13: Graphical mapped ocean station evaporation duct and upper-air profile to land station.

Case b: No evaporation duct or the evaporation duct has been previously mapped.

The profiles of step 1 (gathering the input data) are used to demonstrate how to map two upper-air radiosonde profiles. You can see from these profiles, figures 7-14 and 7-15, that an evaporation duct exists in each. Thus, we will assume that the 0- and 6-meter levels have been mapped in step 2 (and not displayed here), so we need only consider levels higher than 6 meters in height.

Of prime importance is that similar anomalous refraction features be mapped between profiles and the mapped profiles ultimately contain the same number of levels. The purpose of saving the refraction description during step 1 is to aid you in determining what anomalous features are similar.

Profile 1		
@label 20Jun96 – 2200Z		
@height meters		
@range 0 kilometers		
.00	374.49	Calculated evap
6.00	356.74	Trap
17.18	341.35	Normal
1091.59	443.92	Normal
1910.49	552.11	Super
2044.78	555.90	Sub
2128.38	589.49	Normal
2846.28	681.72	Normal
3366.59	741.04	Normal
3655.54	774.70	Normal
3890.70	796.71	Normal
4392.21	863.68	Normal
4538.49	884.73	Normal
5288.29	990.69	Normal
6023.27	1091.27	Normal
6906.71	1217.22	Normal

Summary of Profile 1

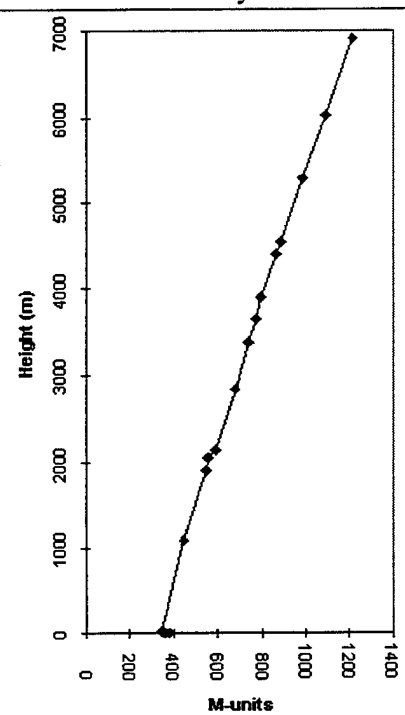


Figure 7-14: Profile 1 with graphical summary.

Profile 2

@label 20Jun96 – 2205Z
@height meters
@range 0 kilometers

.00	356.83	Calculated evap
6.00	349.55	Trap
248.05	342.44	Trap
1585.46	500.50	Normal
1685.72	510.85	Normal
1869.10	532.65	Normal
2353.43	597.63	Normal
2538.66	621.72	Normal
2795.18	648.67	Sub
2806.49	650.92	Normal
3069.79	686.05	Normal
4679.15	912.14	Normal
5050.36	963.86	Normal

Summary of Profile 2

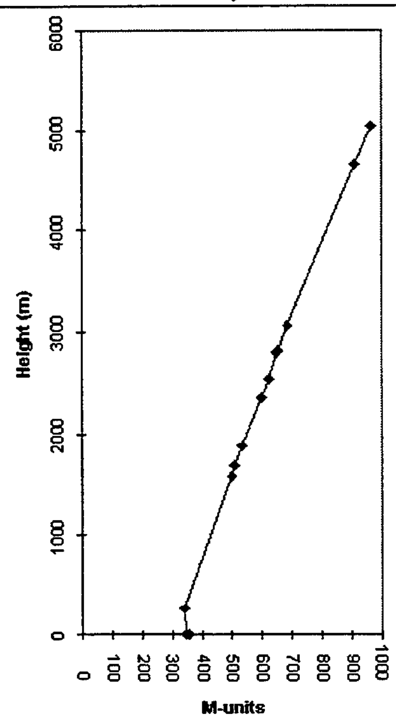


Figure 7-15: Profile 2 with graphical summary.

Starting at the lowest elevation in profile 1, we look for any super-refractive, sub-refractive, or trapping layers. AREPS labels the layers such that the label applies to the bottom of the layer. That is, the super-refractive layer in profile 1 has a top at 2044.78 meters and a bottom at 1091.59 meters. We examine profile 2 to see if there may be any corresponding super-refractive layer at or near these elevations. In this case there is not. You must now determine what is the most likely demise of this super-refractive layer. Figure 7-16 illustrates three possible scenarios: the layer remains level with range, the layer slopes upward with range, and the layer slopes downward with range. As you might expect, there are many more possibilities than just these three. Therefore, it is up to you to determine which is meteorologically most likely to occur. Once you have decided how you will map the level, use M-unit interpolation to insert the necessary point(s) into profile 2. For the interpolation algorithm, refer to mapping the upper-air radiosonde, case a.

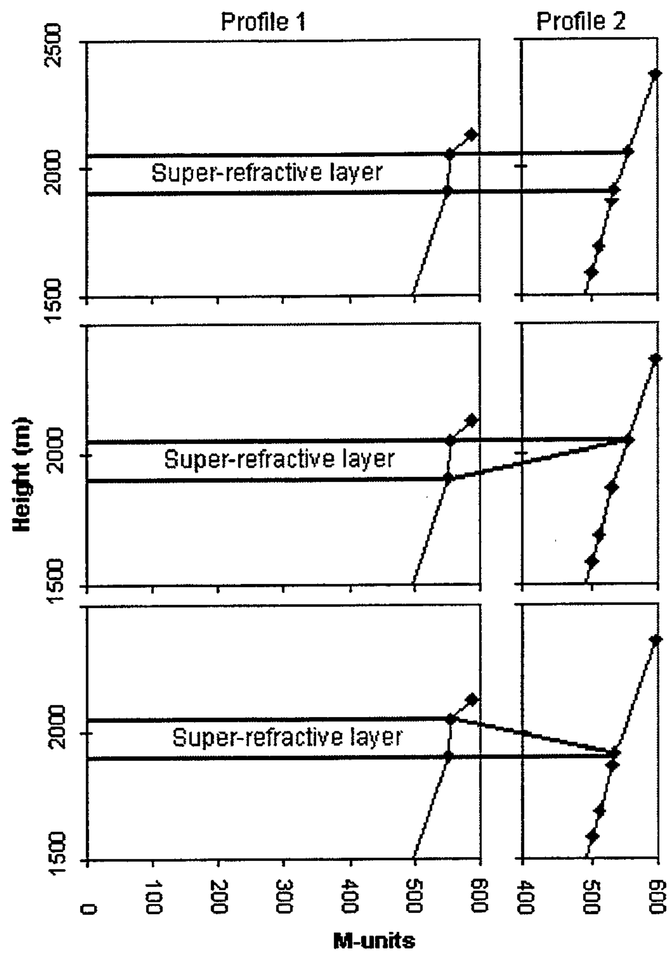


Figure 7-16: Possible super-refractive layer geometries.

Once the lowest anomalous feature of profile 1 has been mapped into profile 2, you will repeat the procedure and map the lowest anomalous feature of profile 2 into profile 1. For this example, the anomalous feature in profile 2 is the trapping layer with its top at 248.05 meters. Again, the figure 7-17 offers several mapping possibilities.

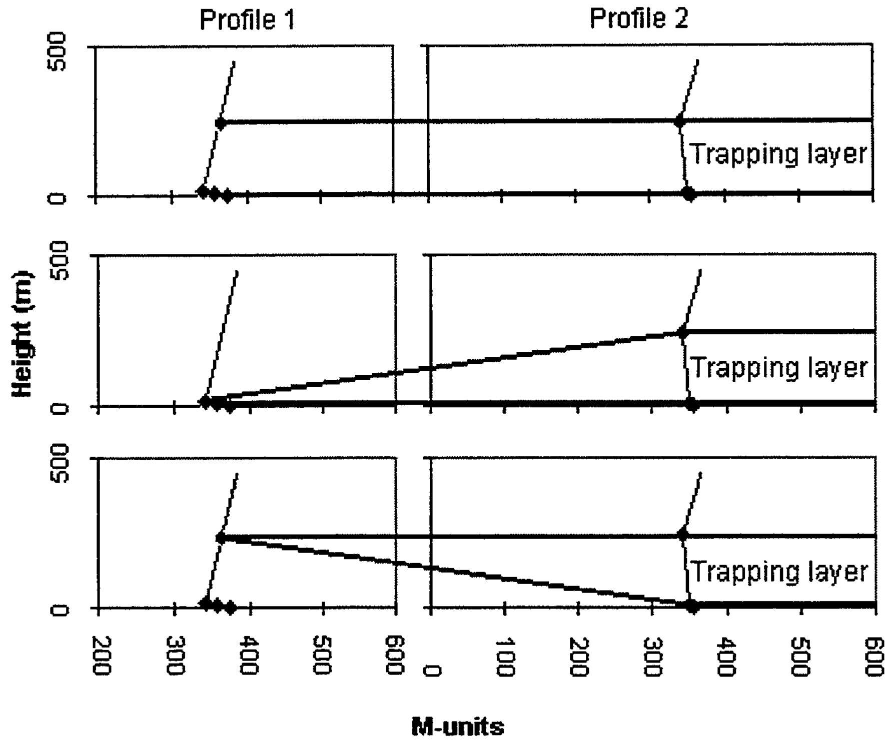


Figure 7-17: Possible trapping layer geometries.

After mapping the lowest anomalous feature of profile 2 into profile 1, the process is repeated with the next highest anomalous feature.

Once all the anomalous feature levels have been mapped between profiles, you will then go back to the lowest normal level in profile 1e and start the process over again, mapping all the normal levels upward until you have reached the top of the highest profile. The mapping may be from one existing level on one profile to an existing level on the other profile or you may insert new levels into the profiles using interpolation to determine the necessary M-unit value. Bear in mind that you must ultimately end up with equal numbers of levels in each profile. Figure 7-18 illustrates one possible mapping of these two profiles. In the illustration, note that there is only one feature that exists and maps directly between both profiles. It's the sub-refractive layer. Note also that no additional levels were inserted using the interpolation technique. Rather, we elected to map the super-refractive layer to an existing level in profile 2. It is a very good idea to keep the number of levels in the profiles to the absolute minimum as increasing the number of levels will not add any accuracy to the propagation model calculations but will cause the models to run more slowly.

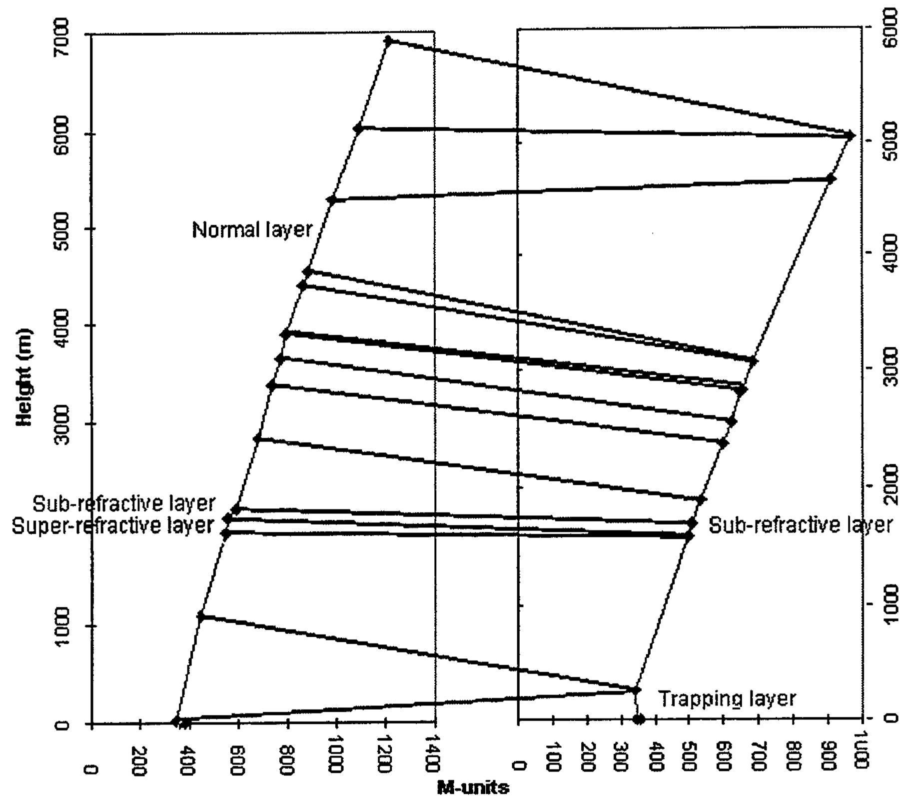


Figure 7-18: Possible trapping layer geometries.

The final profiles will now contain the level values given in table 7-19. The levels in bold text are those inserted during the mapping to ensure both profiles ultimately contain the same number of levels.

Table 7-19: Mapped upper-air profiles between two stations.

Profile 1			Profile 2		
.00	374.49	Calculated evap	.00	356.83	Calculated evap
6.00	356.74	Trap	6.00	349.55	Trap
17.18	341.35	Normal	248.05	342.44	Trap
1091.59	443.92	Normal	**248.05**	**342.44**	**Inserted**
1910.49	552.11	Super	1585.46	500.50	Normal
2044.78	555.90	Sub	**1585.46**	**500.50**	**Inserted**
2128.38	589.49	Normal	1685.10	510.85	Normal

Table 7-19 (Cont): Mapped upper-air profiles between two stations.

Profile 1			Profile 2		
2846.28	681.72	Normal	1869.10	532.65	Normal
3366.59	741.04	Normal	2353.43	597.63	Normal
3655.54	774.70	Normal	2538.66	621.72	Normal
3890.70	**796.71**	**Inserted**	2795.18	648.67	Sub
3890.70	796.71	Normal	2806.49	650.92	Normal
4392.21	863.68	Normal	3069.79	686.05	Normal
4538.49	884.73	Normal	**3069.79**	**686.05**	**Inserted**
5288.29	990.69	Normal	4679.15	912.14	Normal
6023.27	1091.27	Normal	**5050.36**	**963.86**	**Inserted**
6906.71	1217.22		5050.36	963.86	

▶ Step 4: Merging the Profiles into One File

Once all the profiles have been mapped, it is time to combine the individual profiles you have been editing in the Notepad windows and insert the necessary keywording. Figure 7-19 illustrates the two Notepad windows containing the mapped profiles we were mapping in the upper-air case b.

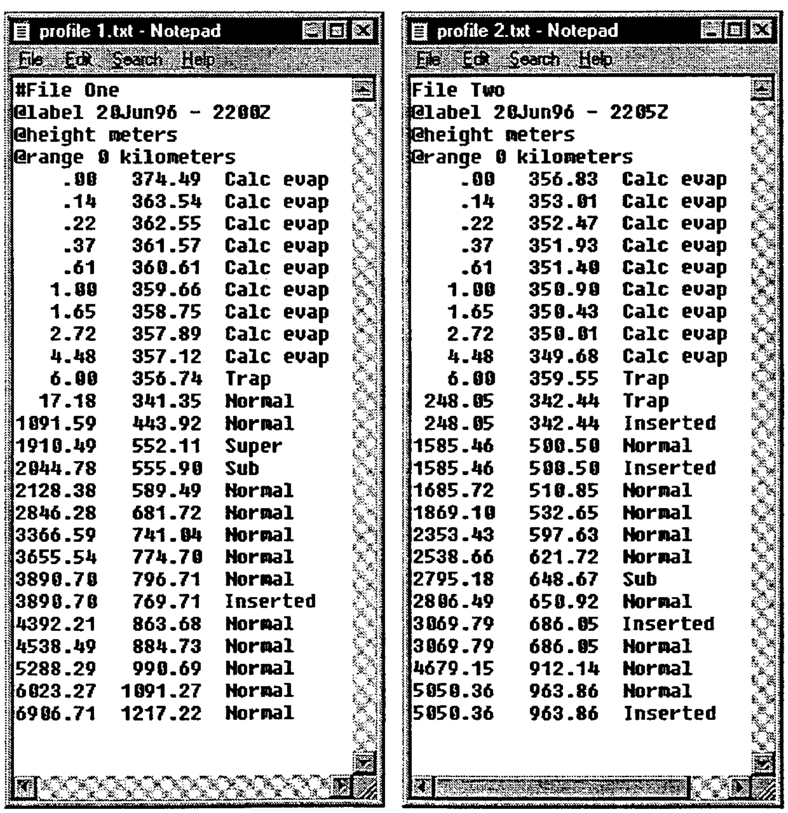


Figure 7-19: Notepad windows for the mapped file 1 and file 2.

► To combine the two files.

Steps	Comments
1	Open a new Notepad window.
2	Assuming profile 1 is closest to the transmitter, copy the contents of file 1 onto the clipboard and then paste them into file 3.
3	Copy the @range line and the height versus M-unit lines of file 2 onto the clipboard and then paste them into file 3. Keep a few blank lines between the pastes.
4	Replace the 0 in the @range 0 kilometers line associated with file 2, with the distance between profiles.
5	While not necessary, you may delete the layer's refractive description labels.
6	Save file 3 with any name you wish into the AREPS environment folder, but use an .ENV extension.

To use this range dependent environmental input file, select it from the environments dropdown menu in the AREPS project window.

TERRAIN

As the default, AREPS uses digital terrain elevation data from the National Imagery and Mapping Agency (NIMA). The normal distribution of DTED data is via CD-ROMs. In addition to DTED terrain data, AREPS is capable of using terrain data you specify yourself. You may use the terrain window to enter your own data and save it in a format usable by AREPS. Since these terrain data are stored in and read from an ASCII text file, you may also choose to create your own terrain data file externally to the AREPS program using an ASCII text editor such as Notepad. Be sure to follow the specifications of an AREPS terrain file when making your own file in this fashion.

AREPS allows for a number of options in the consideration and management of the terrain data. For a detailed discussion of these options, refer to chapter 6 (Options window).

DTED Terrain Data

Digital Terrain Elevation Data are a uniform matrix of terrain elevation values, providing basic quantitative data for systems that require terrain elevation, slope, and/or gross surface roughness information.

NIMA maintains a general help desk that serves as a primary entry point for questions about products or services and as the primary customer advocate. The general help desk is available 24 hours a day. The general help desk address is:

NIMA General Help Desk (L-52)
3200 South Second Street
St. Louis, MO 63118-3399

Contact telephone numbers are:
DSN 490-1236
Toll free 1-800-455-0899
Commercial (314) 260-1236
Fax (314) 260-1128
DSN fax 490-1128

NIMA provides their DTED data in level 0, level 1, and level 2 formats. Level 0 spacing is 30 arc seconds in horizontal resolution (approximately 1 kilometer). DTED level 0 data is unlimited distribution and may be obtained directly from NIMA's public Internet homepage. DTED level 1 spacing is 3 arc seconds in horizontal resolution (approximately 100 meters). Level 2 post spacing is 1 arc seconds in horizontal resolution (approximately 30 meters). Level 1 and 2 data are limited distribution. For this reason, DTED data are not and may not be distributed with AREPS. If you have a connection to the Secure Internet Protocol Router Network (SIPRNET), you may download the DTED level 1 and 2 data directly from NIMA's SIPRNET homepage. In

addition, NIMA provides terrain data in other formats such as raster graphics. AREPS will accept DTED level 0, 1, and 2 coverage only. You may choose your DTED level by selecting the **Terrain** tab from the **Options** menu.

DTED Folder Structure

When AREPS uses DTED data from a CD-ROM, they are copied to the hard disk in the same folder structure as on the CD-ROM itself. Should you obtain your DTED data by downloading from the NIMA Internet or SIPRNET homepages, it is important you recognize this folder structure as you will need to reproduce it yourself and copy your downloaded data into it. Under the DTED folder, illustrated in figure 8-1, are subfolders named E003, E004, W114, etc. (note 3 digits), where the W and E represent west and east and the 003, 004, and 114 represent the whole degrees of longitude. Within each of these subfolders, the file naming convention is N32.DTX, S15.DTX, etc., where the N and S represent north and south and the 32 and 15 represent whole degrees of latitude. The file extension of .DTX represents the DTED level, where .DT0 is level 0 data, .DT1 is level 1 data, and .DT2 is level 2 data.

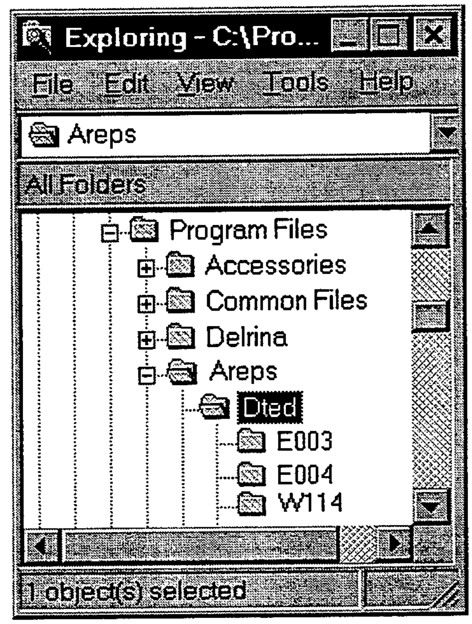


Figure 8-1: DTED folder structure.

Terrain CD-ROM File Manager Window

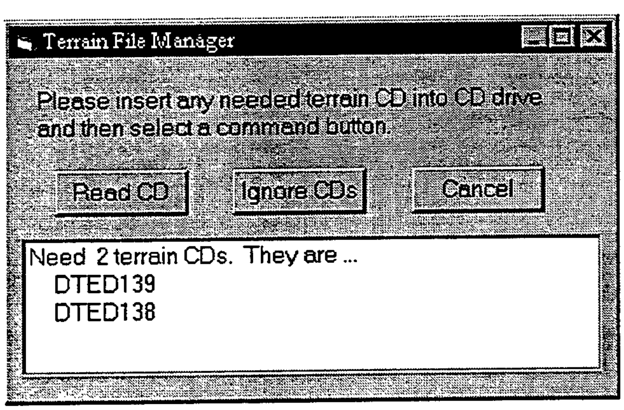


Figure 8-2: Terrain File Manager window.

When a project is executed, its terrain data requirements are examined. If you are using the DTED CD-ROMs for your terrain data and the data do not already exist in your terrain folder, a terrain file manager window, figure 8-2, will open. The total number of CD-ROM disks the project requires and a listing of these disks shows in the window. The CD-ROM number is that assigned by NIMA. Insert one of the CD-ROMs into the CD drive drawer and click the **Read CD**

command button. The order in which you insert disks is not important. You may also click the **Cancel** command button, in which case you will be returned to the project window, or you may click the Ignore CDs command button and the project will continue to execute but without considering terrain effects.

My Own Terrain

AREPS is capable of using terrain data you specify yourself. You may use the terrain window, figure 8-3, to enter your own terrain data and save them in a format usable by AREPS. In addition, you may use this window to edit a terrain file created from DTED data.

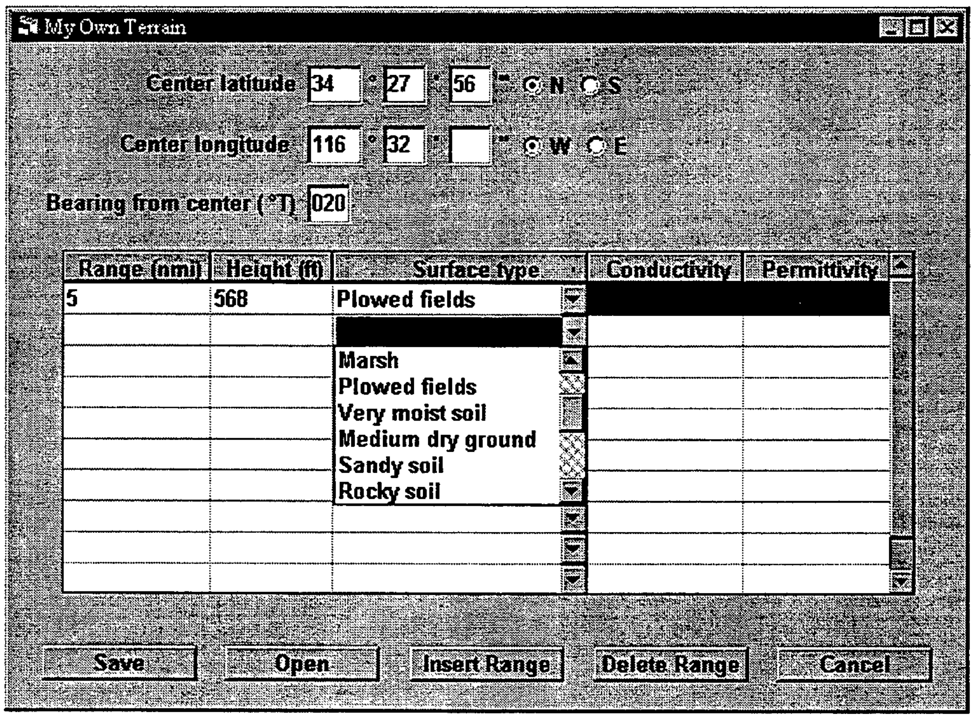


Figure 8-3: Terrain window.

Center Location

The center location is the latitude and longitude of the first terrain point. Click on one of the option buttons adjacent to the seconds input field to select the north, south, east, and west quadrant.

Bearing from Center

The bearing is the azimuth along which the terrain height data applies. The bearing is in whole degrees relative to true north. AREPS 1.0 allows you to specify your own terrain along a single bearing. If you have requested more than one bearing and are

also using your own terrain, you will receive a warning notice, the number of bearings will be automatically set to one, and the project will continue.

Terrain Range and Height

The first column of the terrain tabular form contains range values. The values must be increasing in range. The units of range may be feet, yards, meters, nautical miles, statute miles, kilometers, and kiloyards. To change the units of the column, right click on the column label. The value of the first range must be zero.

The second column of the terrain tabular form contains height values. The units of height may be feet or meters. To change the units of the column, right click on the column label.

Surface Type

Before you continue, for frequencies above 100 MHz, please understand that surface types have minimal influence upon propagation, and for the vast majority of cases, you need not be concerned with a surface type. In addition, AREPS assumes a perfect conducting surface for horizontally polarized antennas and any specified surface type is ignored.

Should you be concerned about surface types for vertically polarized antennas, however, AREPS uses the surface conditions as defined by the International Telecommunication Union, International Radio Consultative Committee (CCIR). These conditions are broken into seven categories based upon surface characteristics. For your convenience, we have provided plain language descriptors that fall within the seven categories. These descriptors are given in table 8-1.

Table 8-1: Surface type descriptors.

Sea water	Fresh water	Sandy loam	Marsh
Plowed fields	Very moist soil	Medium dry ground	Sandy soil
Rocky soil	Medium sized towns	Very dry ground	Granite mountains
Industrial areas	New ice	Old ice	Self-defined

You may select one of these descriptors from the surface type dropdown menu. Based upon the surface descriptor you have selected and the frequency of the project's transmitter, a proper calculation of surface conductivity and permittivity is made.

If you select one of the plain language descriptors, the permittivity and conductivity columns of the tabular form will be filled with the word **Compute**, the background color of these columns will change to green, and you will not have access to these columns. If you select **Self-defined** from the menu, you must specifically enter a surface permittivity and conductivity value.

A surface type must be associated with the first range. If you are using DTED terrain data and the terrain elevation at the first range is zero, seawater is assumed for the entire path, even if nonzero terrain elevations are subsequently encountered. If the elevation at the first range is not zero, medium dry ground is assumed for the entire path, even if zero elevations are subsequently encountered. Please understand this assumption is made because no data exists on the DTED CD-ROM to say what the surface type is for any elevation.

If you are using DTED data and don't want this assumption, you must specify the surface type yourself.

▶ **To specify a surface type with DTED data.**

Steps	Comment
1	Execute the project to have AREPS read the DTED data and create the terrain files. By default, terrain files are not saved so you must choose to save them by selecting the **Save Terrain in ASCII text format** item from the **Save/Edit tab** on the **Options** menu.
2	After the terrain files are created for all project bearings, open each file individually in the terrain window, select a different surface type for the first (and any other) range, then save the file.
3	Re-execute the project.

Surface Electrical Characteristics

The fourth and fifth columns of the terrain tabular form contain the surface electrical characteristics expressed as permittivity and conductivity.

The electrical characteristics of any medium may be expressed by three parameters. The first parameter is the permeability, the rate of diffusion of a substance such as a gas or water through a porous material. The second parameter is the permittivity, the ratio of the electric flux density produced by an electric field in a medium to that produced in a vacuum by the same field. The third parameter is the conductivity, a measure of how a particular substance conducts electricity. They jointly influence wave propagation. The permeability of the ground can normally be regarded as equal to free-space permeability so for most propagation considerations, we are only concerned with permittivity and conductivity.

The effective values of the constants of the ground are determined by the nature of the soil, by the soils moisture content and temperature, by the frequency, by the general geological structure of the ground, and by the effective depth of penetration and

lateral spread of the waves. While it has been established by numerous measurements that the values of the electrical characteristics vary with the nature of the soil, it is seems probable that the variation may be due not so much by the chemical composition of the soil as its ability to absorb and retain moisture. The moisture content of a particular soil may, however, vary considerably from one site to another, due to differences in the general geological formations that provide better drainage in one case than another.

Typical values of conductivity and permittivity for different ground types are generally determined by laboratory measurements of a particular homogeneous soil type. In nature, however, the surface and sub-surface are rarely homogeneous, but rather consist of two or more layers of different thickness and different conductivity and permittivity. AREPS version 1.0 considers only values for a homogeneous surface.

Command Buttons

Across the bottom of the terrain window are command buttons. You may use these command buttons to perform various functions.

Open

The **Open** command button allows you to open a terrain file for editing. The Windows 95/NT Explorer window opens allowing you to browse your entire folder structure for the desired file. The terrain file may be one you previously created yourself or it may be a file created by AREPS while reading data from a DTED CD-ROM.

Save

The **Save** command button saves the data from the terrain tabular form into an ASCII text file readable by AREPS. You may name the file as you wish but you are limited to 48 characters. The file will be saved in the environment directory. AREPS will append the .TER extension onto the file name you specify. For example, if you specify *MyTerrain.ter*, the file name will be *MyTerrain.ter.ter*.

Insert and Delete Range

The **Insert Range** command button allows you to open a blank range input point prior to the current cursor location. You may then enter a new range, height, and surface condition. The **Delete Range** command button removes the range at the current cursor location. As ranges are inserted and deleted, proper input limits show in the status bar's left panel.

Cancel

The **Cancel** command button ignores all your entries and editing actions and closes the Terrain window.

Terrain File Format

The following describes the considerations, structure and restrictions on creating your own terrain file.

Terrain File Name

Terrain files are created in three ways and the naming conventions are slightly different for each.

1. You may desire access to the terrain data for use in your own evaluation program. Rather than creating a program yourself to read the DTED CD-ROMs, you may have AREPS save the terrain's height and range data (one file for each project bearing) in the project's folder as an optional ASCII text file. By default, the file name is *TERRNddd.TER*, where the *ddd* represents the bearing in whole degrees relative to true north. You may choose to use a name prefix other than *TERRN*, however. You may use any valid Windows95/NT file name character including spaces. AREPS will append the *ddd* and the *.TER* extension onto the file name you specify. For example, if you specify *terrain.000*, the file name will be *terrain.000ddd.TER*.

2. You may create your own file (or edit a DTED CD-ROM file) in the terrain window. There is no default name. AREPS will append the .TER extension onto the file name you specify. For example, if you specify *MyTerrain.ter*, the file name will be *MyTerrain.ter.ter*.

3. You may create your own terrain file external to the AREPS program. When doing so, be sure to follow the proper file conventions. Of course, you may name the file as you choose using any valid Windows95/NT file name character including spaces. AREPS will not modify your file's name.

Terrain File Considerations

AREPS 1.0 allows you to specify your own terrain along a single bearing. If you have requested more than one bearing and are also using your own terrain, you will receive a warning notice, the number of bearings will be automatically set to one, and the project will continue.

When using your own terrain, the terrain map in the lower right corner of the decision aid does not make sense. Therefore, if you use your own terrain, the terrain map option will automatically be set to "No map."

The terrain file may be created independently of any particular project so the maximum terrain range may not coincide with the maximum display range. In this case, you may choose to continue the display, have the display range automatically adjusted to the maximum terrain range, or cancel the display. If you choose to continue the display, please understand any propagation loss or probability of detection/ESM intercepts

beyond your maximum display range may or may not be in error based upon your refractive conditions.

Terrain File Restrictions

A terrain profile is defined as couplets of range and height. The maximum number of couplets for AREPS is unlimited. The height and range values need not be separated by a comma or other delimiter but must be separated by at least one space. Any characters beyond the height value are ignored. The value of the first range must be zero.

Key Words and Symbols

The terrain file contains a number of key words and symbols (keywords are case insenitive) which describe the data. These key words and symbols are:

– A line beginning with a # is a comment and is ignored by AREPS. In additon, blank lines are ignored by AREPS.

@latitude – signifies the latitude of the terrain location. Following this keyword is the latitude value in the format DD MM SS H where DD is whole degrees, MM is whole minutes, SS is whole seconds, and H is the hemisphere either N for north or S for south. The minutes and seconds need not be present and DD may be a single character (5 vice 05). As AREPS version 1.0 allows terrain along a single bearing, the latitude keyword is used only for display purposes in the terrain window.

@longitude – signifies the longitude of the terrain location. Following this keyword is the longitude value in the format DDD MM SS H, where DDD is whole degrees, MM is whole minutes, SS is whole seconds, and H is the hemisphere, either W for west or E for east. The minutes and seconds need not be present and DDD may be either one or two characters (5 vice 005 or 20 vice 020). As AREPS version 1.0 allows terrain along a single bearing, the longitude keyword is used only for display purposes in the terrain window.

@bearing – signifies the azimuth along which the terrain height data applies. Following this keyword is the bearing value in the format DDD, where DDD is whole degrees relative to true north. DDD may be one, two, or three characters (5 vice 005 or 20 vice 020). Any characters beyond the DDD are ignored. As AREPS version 1.0 allows terrain along a single bearing, the bearing keyword is used only for display purposes in the terrain window.

@height – signifies the units for all values of height. If the @height keyword is not present, meters are assumed. Following this keyword is the unit keyword. The unit keyword may be ft or m. If the unit keyword is not present, meters are assumed. This keyword must appear before any height value.

@range – signifies the units for values of range. If the @range keyword is not present, meters are assumed. Following this keyword is the range unit keyword. The unit keyword may be yd, kyd; m, km; nm or nmi; or sm. If the unit keyword is not present, meters are assumed. Some examples are @range sm, @RANGE yd, and @range nmi.

@ground – signifies the surface type. When the @ground keyword is used, the surface type applies at the range immediately following the keyword. It is not necessary to have a surface type specified for every range. Once a surface type is specified, it is assumed constant for all following ranges until it is specified again. If the @ground keyword is not present, seawater is assumed. Following this keyword is the surface type keyword. The surface type keywords (spelling but not case sensitive) are specified in table 8-1. If the surface type keyword is Self-defined, it must be followed by two values, the first for the surface permittivity and the second for surface conductivity. These two values need not be separated by a comma or other delimiter but must be separated by at least one space. If these two values are not present, an error is announced.

Figure 8-4 illustrates a small portion of a sample terrain file.

```
# AREPS Version [1.0.0] terrain profile
@Latitude 44 30 00 N
@Longitude 014 00 00 E
@Bearing 010 (°T)
@Range km
@Height m
@ground Self-defined 50 2
   0.000    25.00
   0.100    78.00
   0.200   145.00
@ground Industrial areas
   0.300   200.00
   0.400   140.00
   0.501    80.00
   0.601    43.00
   0.701    43.00
   0.801     0.00
   0.901    92.00
```

Figure 8-4: Sample terrain file format.

DECISION AIDS

Coverage Display Window

Coverage decision aids of radar detection, ESM intercept, or communications are shown in the coverage display window, illustrated in figure 9-1. Various pieces of information show on the right side of the decision aid. Some of this information is project dependent, such as radar name, target name, environment file name, etc. Other information shows as the mouse cursor is moved about the display. This information includes height, range, latitude, longitude, bearing, propagation loss, etc.

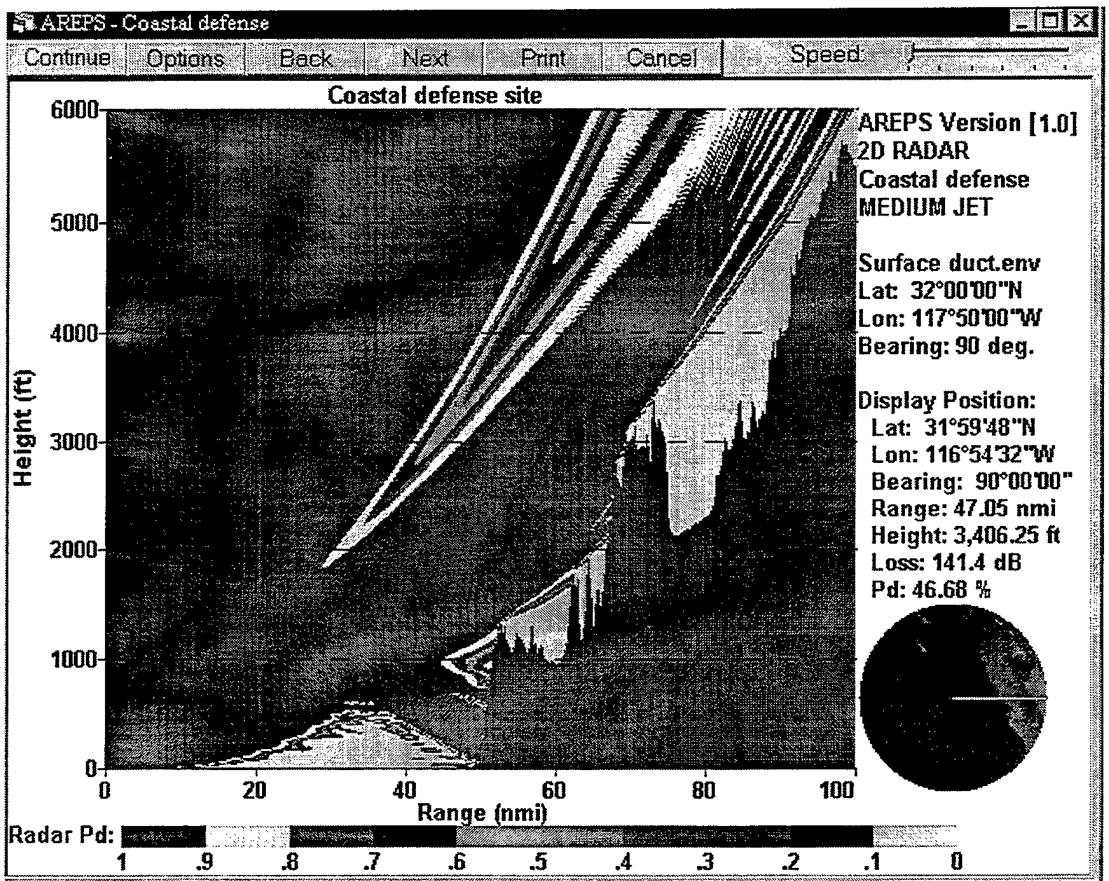


Figure 9-1: Coverage display window.

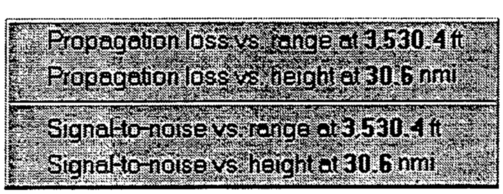


Figure 9-2: Display options pop-up menu.

Selecting the options button from the toolbar or right clicking anywhere within the coverage display will open a display options pop-up menu, illustrated in figure 9-2. If you select the options button, you are asked for the desired height or range. If you right

click the mouse, the display will be for the height and range associated with the mouse cursor's location. You may open as many of these loss displays as you wish.

In order to calculate propagation loss in the extended optics region, a loss at the top of the parabolic equation region is needed for all ranges. Thus, the extended optics region is calculated after the decision aid has reached its final range. You will notice this "two pass" calculation as a blank area in the upper right corner of the decision aid. Once the extended optics calculations are made, the total image of the decision aid is shown.

Display Window Toolbar

Across the top of the display window is a toolbar, figure 9-3, with buttons to control the azimuth display of the decision aid.

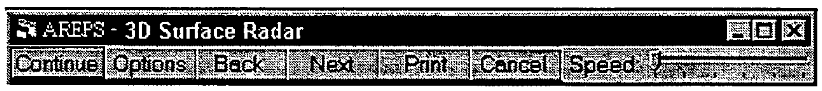


Figure 9-3: Display window toolbar.

With these buttons, you may pause or continue the azimuth display, single step through the decision aids either backward or forward, print a single aid, cancel the display, or change the speed with which the aids are shown. In addition, the options button provides access to propagation loss or signal-to-noise displays in range or height.

Display Window Color Bar

For coverage decision aids, beneath the diagram is a color bar legend for the type of data being displayed. For radar only displays, figure 9-4, the colors represent either probabilities of detection, figure 9-4, or propagation loss, figure 9-5, depending upon the option you choose.

Figure 9-4: Radar probability of detection color bar.

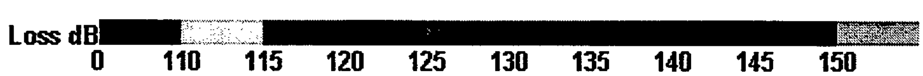


Figure 9-5: Radar propagation loss color bar.

For simultaneous radar and ESM displays, the colors represent greater than 90% and greater then 50% probability of detection and a binary (yes or no) ESM intercept as illustrated in figure 9-6.

Figure 9-6: Radar and ESM color bar.

For the ESM only and communications displays, the colors represent either ESM intercept or communications, yes or no as illustrated in figure 9-7.

Figure 9-7: ESM and communications color bar.

Any area of the coverage diagram that is colored white indicates an area for which no propagation calculations were made.

Coverage Display Options

Coverage display options may be selected from the **Display** tab of the **Options** menu. The height versus range coverage display may be referenced to probability of detection or to propagation loss. You may specify the limit of this reference, the increment of the reference, and how may increments you want. For example, you may choose propagation loss as your reference. You then may select 100 dB as your minimum propagation loss threshold value, 5 dB intervals, and 9 intervals. On your display, you will see 10 boxes on the color bar labeled 0 to 100 dB, 100 to 105 dB, 105 to 110 dB, etc. As another example, you may choose probability of detection as your reference. You may then choose 100 percent as the limit, 20 percent as the interval, and 2 intervals. On the display, you will see 2 boxes on the color bar labeled 1 to .8 and .8 to .6.

To aid you in visualizing the decision aid, you may choose to have height reference lines drawn on the display.

Loss Versus Range Display Window

Rather than a height versus range coverage display, propagation loss or signal-to-noise ratios may be shown in a decibel versus range display, illustrated in figure 9-8. This display is for a constant height. Unlike the coverage display, the contours of electric field strength are represented by horizontal lines. For an EM system to function, the propagation loss must not exceed the threshold, whereas the signal-to-noise ratio must

exceed the threshold. From the Displays tab on the Options menu, you may specify the

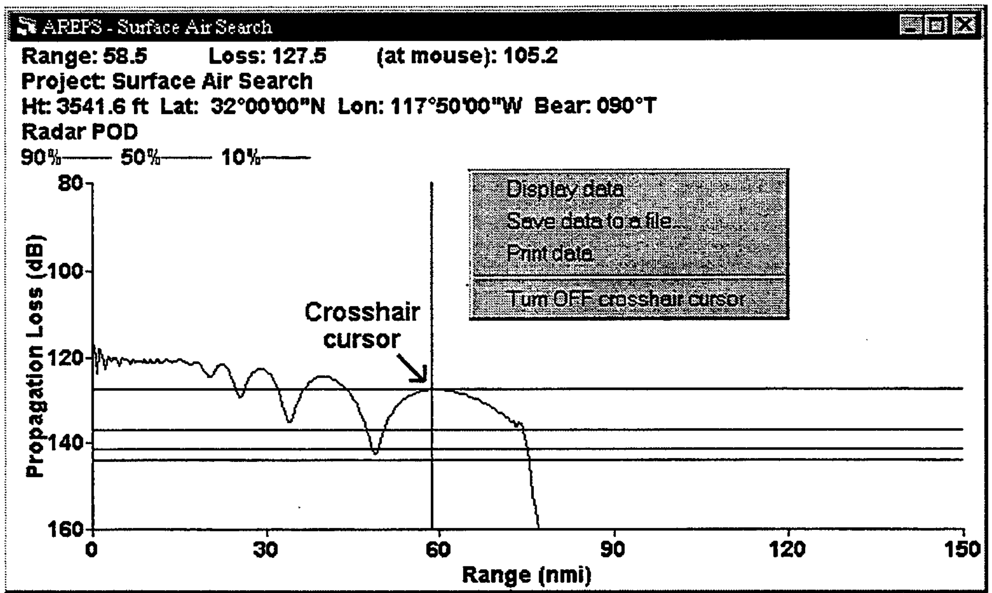


Figure 9-8: Propagation loss versus range display window.

propagation loss or signal-to-noise limits and if you want to display threshold lines.

As the mouse cursor moves over the display, a crosshair cursor follows the mouse and rides along the propagation loss curve. The range and loss values, both at the mouse position and the crosshair position are shown. An options pop-up menu (shown in figure 9-8) is available by right clicking anywhere on the display. If you select **Display Data**, a scrollable window will open so you may view the propagation loss values along the curve. This data window is illustrated in figure 9-10.

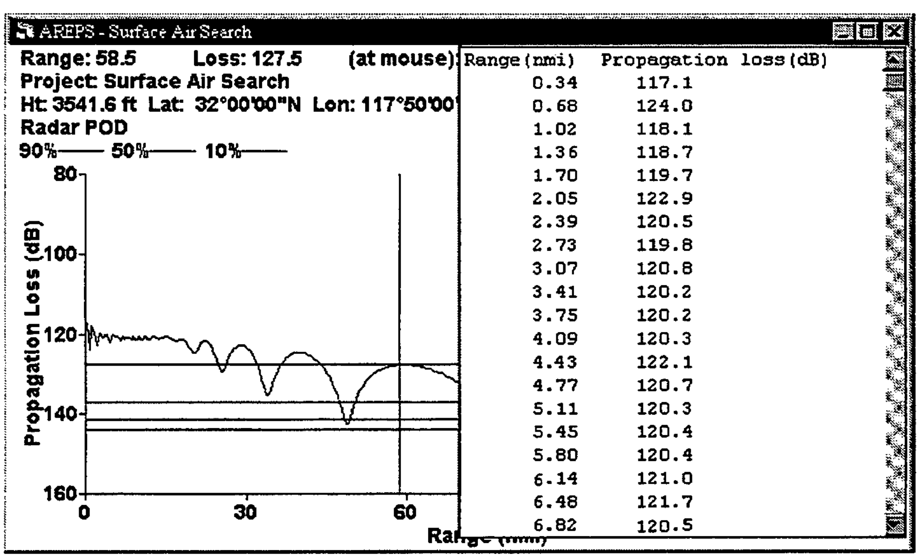


Figure 9-10: Propagation loss versus range display with open data window.

Loss Versus Height Display Window

Rather than a height versus range coverage display, propagation loss or signal-to-noise ratios may be shown in a decibel versus height display, illustrated in figure 9-11. This display is for a constant range. Contours of electric field strength are represented by vertical lines.

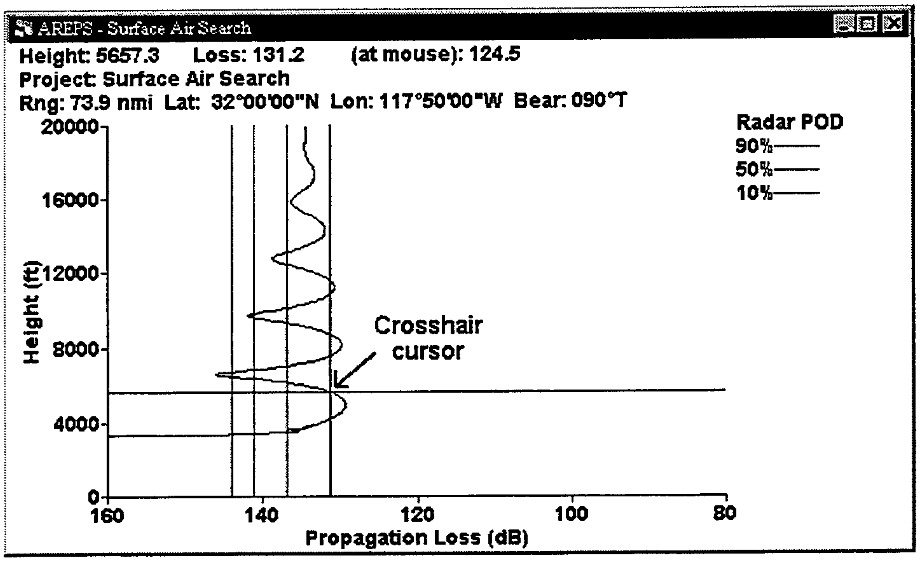


Figure 9-11: Propagation loss versus height display window.

For an EM system to function, the propagation loss must not exceed the threshold, whereas the signal-to-noise ratio must exceed the threshold. You may specify the propagation loss or signal-to-noise limits and if you want to display threshold lines from the **Displays** tab on the **Options** menu.

As the mouse cursor moves over the display, a crosshair cursor follows the mouse and rides along the propagation loss curve. The height and loss values, both at the mouse position and the crosshair position are shown. An options pop-up menu is available by right clicking anywhere on the display.

Loss Versus Range and Height Options

The loss versus range and the loss versus height display may be referenced to propagation loss or to signal-to-noise. You may specify the upper and lower limit of this reference. In addition to the reference, you may also choose to superimpose radar probability of detection, ESM intercept, or communications threshold lines. For ESM only or communications displays, threshold lines will not display when using the signal-to-noise reference. For radar probability of detection, you may choose the maximum threshold, the interval of the threshold, and how many intervals you want. For example, you may choose 100 percent as the maximum probability of detection, 20 percent as the interval, and 2 intervals. On the display, you will see three colored dashed lines corresponding to 100 percent, 80 percent, and 60 percent probability of detection.

TACTICAL APPLICATIONS

Strike and Electronic Counter Measures Considerations

One tactic employed by an attack aircraft in penetrating an enemy target's defenses is to fly as low as possible to remain "beneath" the radar coverage. This may be a valid tactic during nonducting conditions. For surface-based ducting conditions, however, the enemy is given a greater detection range capability for targets flying within the duct than for targets at higher altitudes. Knowledge of the existence and height of a surface-based duct would enable the strike group or aircraft commander to select the optimum altitude for penetration. This would be just above the top of the duct.

In a manner similar to that described for the strike case, an ECM aircraft may adjust its position to maximize the effectiveness of its jammers by using the coverage display. By flying within a duct, the aircraft will be more easily detected but, at the same time, its jamming effectiveness will be greatly enhanced and its standoff range will be greatly extended.

While it may be possible to avoid detection by flying down an interference null, the changing height versus range profile would be more difficult to fly and, if the aircraft were off course or the null pattern changed somewhat, due to the target ship's roll for example, detection would occur. In addition, ship or land targets would usually be defended by several radars operating at different frequencies. The constructive interference pattern for one radar would most likely fill in the destructive interference pattern of the second radar, thereby increasing the likelihood that this maneuver will be unsuccessful.

The decision aid for standard atmospheric conditions, figure 10-1, shows that a strike aircraft flying just above the terrain should not be detected until it is within 18 nautical miles of the defending radar. Should the aircraft be making its ingress at an altitude of 6000 feet, the detection probabilities rapidly increase at ranges beginning at 72 nautical miles from the defending radar. For this standard atmosphere case and neglecting other tactical considerations such as surface-to-air missile threats, the optimum strike altitude is as close to the terrain as the aircraft can safely fly. An ECM jamming aircraft however would have an optimum altitude of 6000 feet as this will provide the greatest standoff range coupled with the greatest jamming effectiveness.

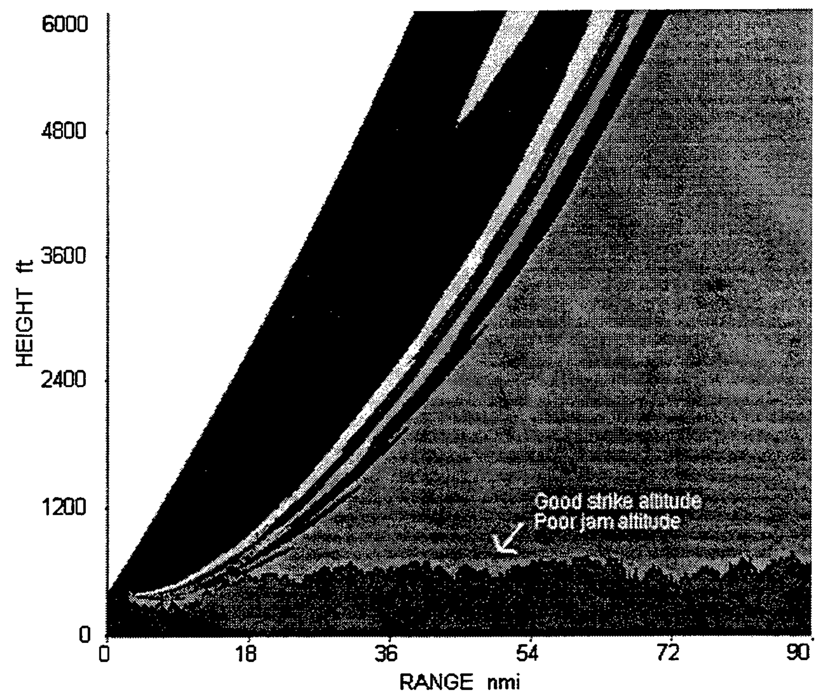


Figure 10-1: Coverage display for standard atmosphere.

Using the same principles under a surface-based ducting environment, illustrated in figure 10-2, if the strike aircraft is flying just above the terrain, the probabilities of detection greatly increase beginning at a range of 80 nautical miles from the defending radar.

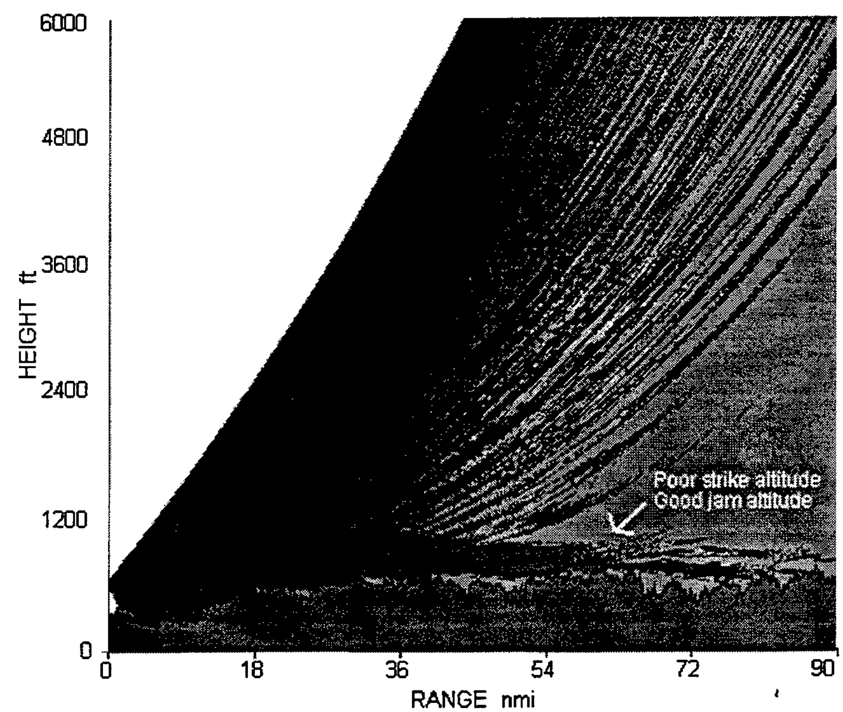


Figure 10-2: Coverage display for a surface-based duct atmosphere.

Note also, should the strike aircraft be making its ingress at an altitude of 6000 feet, the detection probabilities rapidly increase at ranges over 90 nautical miles from the defending radar. Thus, for a surface-based ducting environment, the optimum strike altitude is neither low nor high but just above the duct's top, an altitude of approximately 1000 feet. While a jamming aircraft will have success at high altitudes, its greatest jamming effectiveness is at altitudes closest to the terrain.

Early Warning Aircraft Stationing Considerations

By using the coverage decision aid, the optimum altitude for early warning aircraft can be determined, which will minimize the effects of radar "holes" or "shadow zones" created by elevated ducts or terrain features. It should be remembered that although the duct acts like a waveguide for the energy, this waveguide does not have rigid and impenetrable boundaries, except for the earth's surface in the case of surface-based ducts. Therefore, energy is continually "leaking" from the duct into the hole. In addition, surface-reflected energy may propagate into this hole. While the energy level within a radar hole may be insufficient for radar detection, it may be sufficient for ESM intercept.

The coverage decision aid, figure 10-3, illustrates the principles discussed above. For this case, there is an elevated duct between 19,000 and 20,000 feet. The aircraft is flying within the duct. Extended ranges for high probability of detection can be seen within the duct.

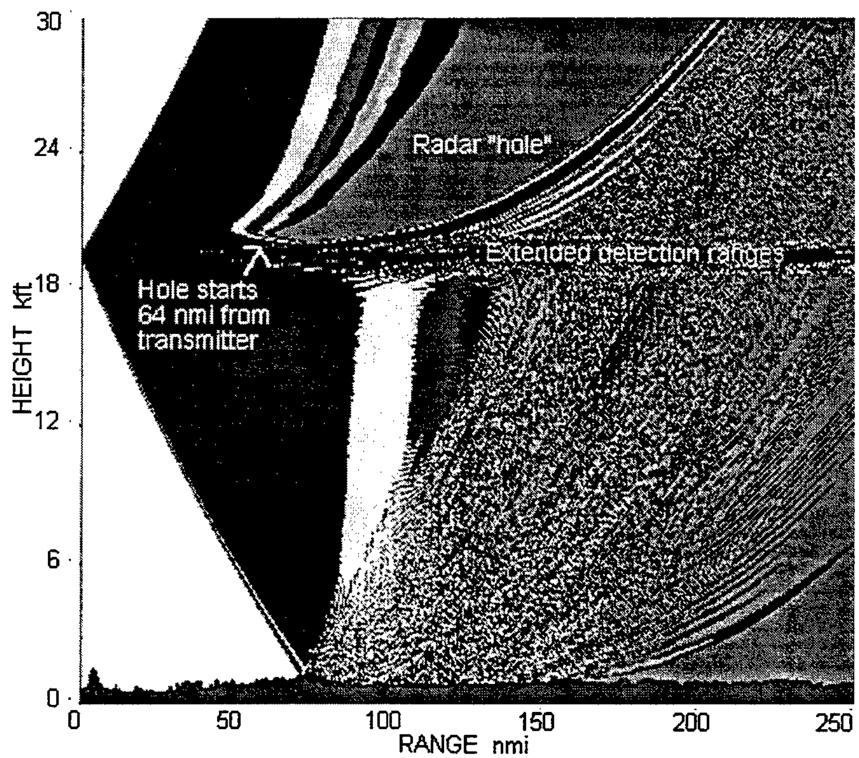


Figure 10-3: Early warning aircraft within an elevated duct.

The radar hole is evident above the duct. In addition, you can see energy leaking upward from the duct, defining a down-range boundary for the hole, and you can see surface-reflected energy reaching the atmosphere above the duct and beyond the down-range hole boundary. Note that for this case, the hole starts at 64 nautical miles from the transmitter.

Tactically, flying within an elevated duct is not desirable, as the aircraft will experience the greatest area of reduced coverage. While it's true the extended ranges within the duct do exist, the likelihood of the target also being within the duct cannot be counted on. In addition, an ESM intercept aircraft could tactically exploit these extended ranges by stationing himself at ranges beyond radar detection but still within ESM intercept ranges.

Now consider the AEW aircraft ascending to an altitude of 25,000 feet, illustrated in figure 10-4. While the radar hole is still present, it starts 95 nautical miles from the transmitter. The higher the transmitter is above the duct, the farther in range the hole will begin. Also notice that extended ranges within the duct are not present. Here again, there is a tactical tradeoff, i.e., no extended ranges but better overall coverage.

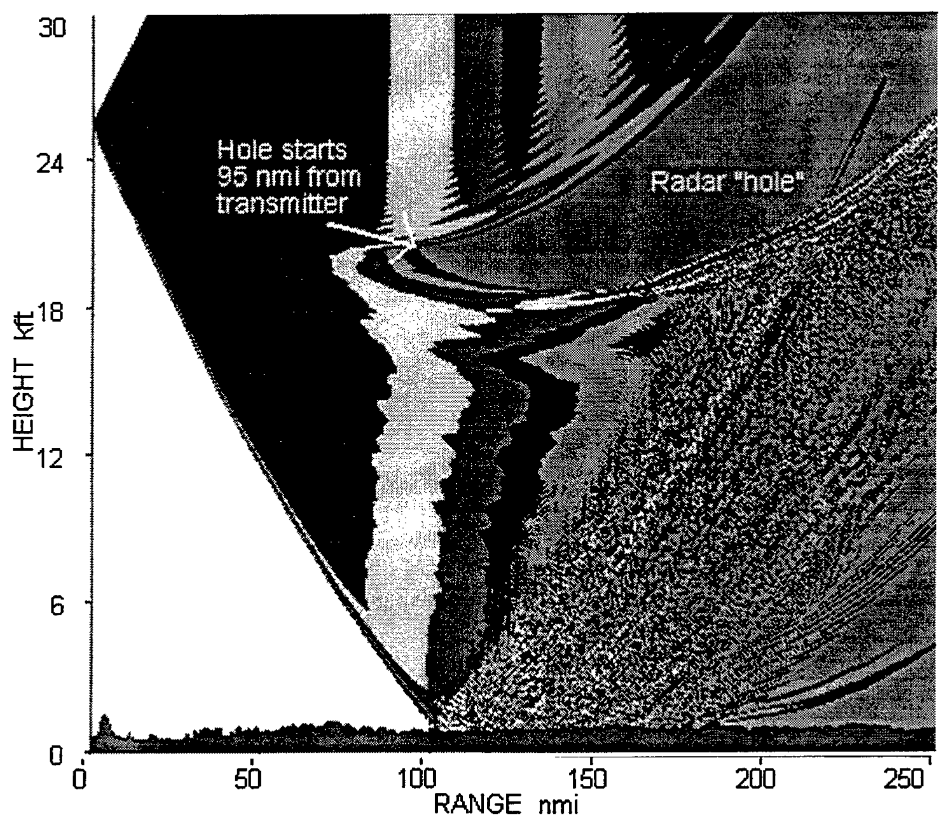


Figure 10-4: Early warning aircraft above an elevated duct.

In figure 10-5, the early warning aircraft positions itself at an altitude of 15,000 feet. Notice that since the transmitter is now below the elevated duct, there are no anomalous propagation effects from the duct, i.e., no extended ranges and no radar hole.

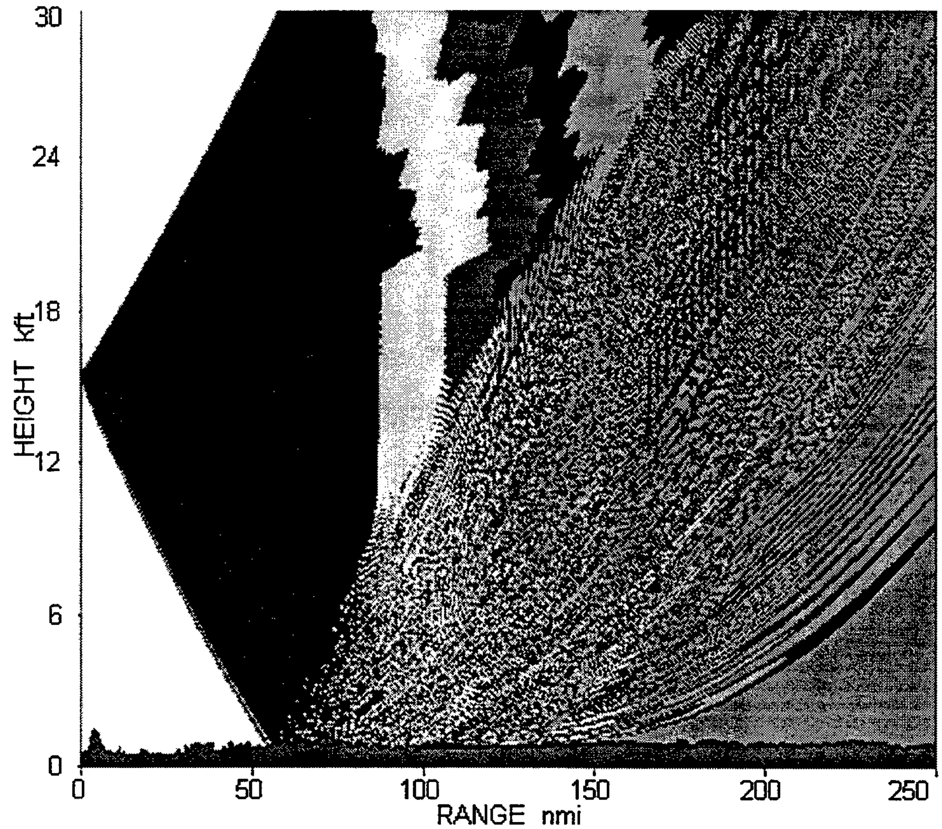


Figure 10-5: Early warning aircraft below an elevated duct.

Thus, as a rule-of-thumb, the positioning of an early warning aircraft in relation to the elevated duct is to fly as high above the duct as possible or fly anywhere below the duct, consistent with other mission objectives including radar/communication horizon, fuel usage, height assignments by traffic control, etc.

While not a part of the tactical application, figure 10-5 illustrates a limitation of the current APM propagation model. Any area of the display that is colored white indicates an area for which no propagation calculations were made. In this case, it is for high angles. A conscious decision was made to ignore these high angles due to computer execution time and memory considerations when employing the parabolic equation model. This limitation should not be a hindrance to tactical applications, however, as refractive effects are negligible above a few degrees from the horizontal. This limitation of the advanced propagation model will be overcome in a future version of APM with the inclusion of the airborne parabolic equation model. No detection of a high-flying target will be a tactical problem when the target is outside the antenna pattern of the transmitter.

Electronic Surveillance Measures (ESM)

Oftentimes it is advantageous to know not only the detection ranges of threat targets but your own vulnerability to ESM intercept by an enemy. For example, you are concerned about detecting a low-flying anti-radiation missile (ARM) but, at the same time, you are concerned about providing the missile's seeker with extended detection range. Likewise, when creating an emissions control plan, for example, a task force, it is of great value to know which systems are most vulnerable to intercept. A tradeoff study of emitters can be made to determine placement and use of emitters to defend your position yet remain undetected for as long as possible. These considerations can be made with the radar/ESM vulnerability display.

The tactical situation could also be applied in a reverse sense. For example, you may be airborne, trying to approach a heavily defended area, giving as little advance notice as possible. You do this by not radiating an EM system except for your downward looking terrain following radar. Using the radar/ESM vulnerability display, you will be able to assess the effects of diffraction over terrain features. While the main beam of the radar is pointed toward the ground, energy is still being radiated outward through the sidelobes. The sidelobe energy could be diffracted forward over steep terrain to an ESM receiver at the defended area, thereby giving unsuspected advanced notice of your arrival.

Consider a mission to approach a hostile coastline and provide AAW surveillance for the protection of an amphibious landing force (illustrated in figure 10-6).

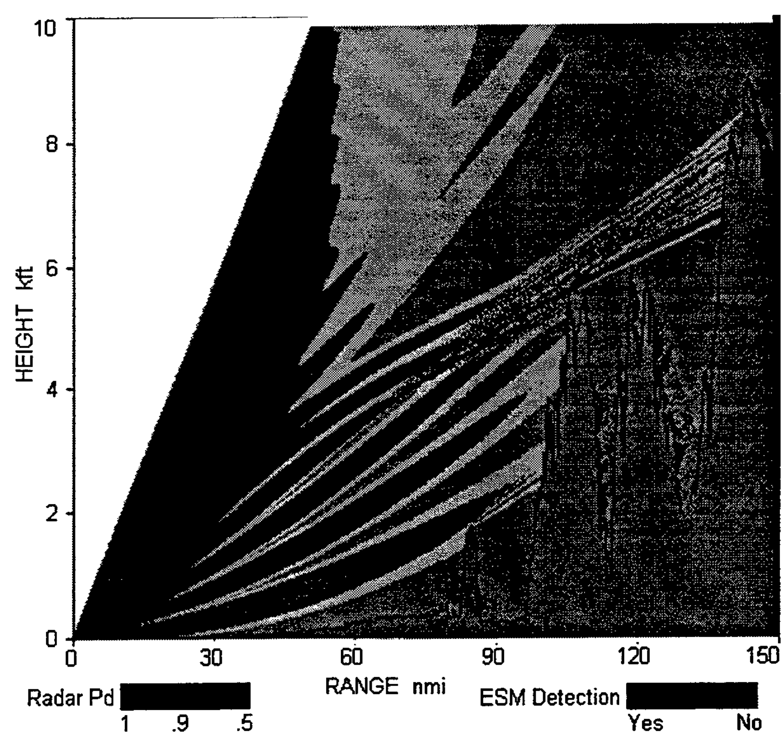


Figure 10-6: Radar and ESM intercept decision aid.

For this mission, it is highly desirable to remain undetected for as long as possible. You anticipate the coastal mountain ranges will provide you cover from ESM intercept. Using the combination radar detection and ESM vulnerability decision aid, you can visualize your detection ranges for the anticipated threat aircraft and also see the vulnerability of your air surveillance radar to a hostile ESM receiver. In this example, the environment is a surface-based duct at your ship's location that rises to become an elevated duct over the coastal terrain. This ducting condition provides fairly reasonable detection for targets at ranges of 100 nautical miles. As you would expect, your radar is vulnerable to intercept at even greater ranges. You can see, however, an ESM receiver that is located 120 nautical miles away and within a valley beyond 2 mountain ranges, is still capable of intercepting your radar's energy. The coastal mountains do not provide the intercept protection you were expecting. For this case, the mission commander may choose to use an airborne platform for AAW surveillance instead of a ship platform.

UHF/VHF Communications

It is commonly thought that UHF/VHF communications is a line-of-sight event. This is true under standard atmospheric conditions. Consider a tactical application such as a ship trying to communicate with ground troops over a water and terrain path. The communications decision aid shown in figure 10-7, for a standard atmosphere indicates a loss of surface communications at a range of approximately 8 nautical miles. Communications is not regained until 25 nautical miles from the ship with the troops at an altitude of 250 feet. By examining the areas of no communications, the ashore forces can determine a good location to establish a command center with adequate communications to the afloat platform or to aid in troop positioning.

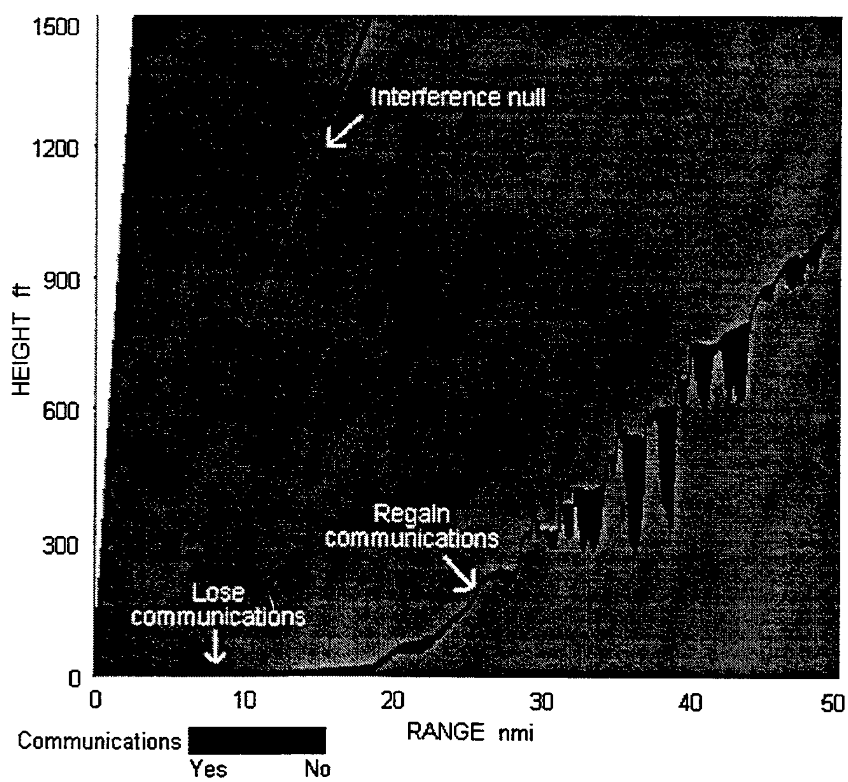


Figure 10-7: UHF communications decision aid.

Tactics for ASW helicopter operations may also benefit from the knowledge of ducting or nonducting conditions. For example, under standard atmospheric conditions as illustrated in figure 10-8, the helicopter (at an altitude of approximately 50 feet) can maintain both ASW surveillance with its dipping sonar and communicate with the ship at a range of approximately 33 nautical miles.

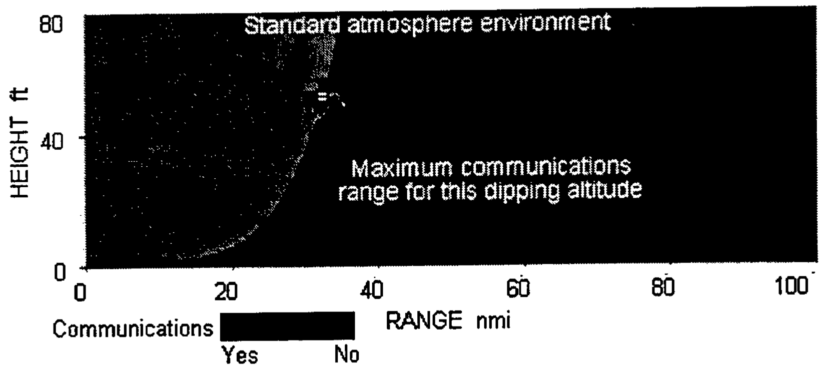


Figure 10-8: UHF communications under standard atmosphere conditions.

Under surface-based ducting conditions, figure 10-9, the helicopter at the same altitude could extend the communication ranges well beyond 60 nautical miles. In addition, the decision aid shows surface-based ducting skip zones that could preclude communications at certain ranges.

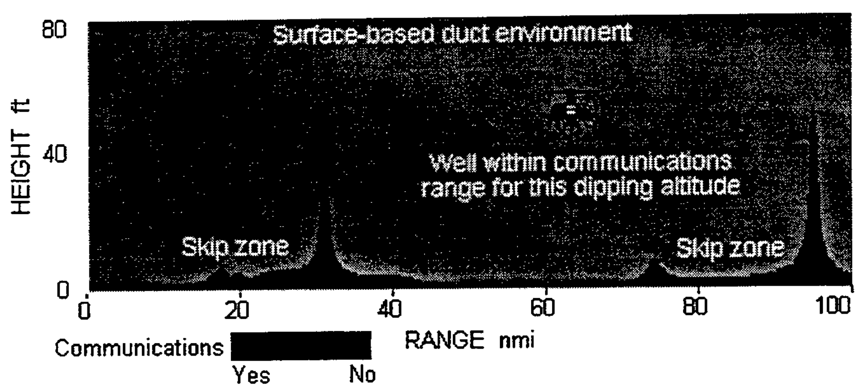


Figure 10-9: UHF communications under surface-based ducting conditions.

Use for Hardware Maintenance

An operator will experience days when detection of radar targets or communication with other units over the horizon is possible and days when extended ranges are not possible. In addition, the radar operator will experience false targets or radar "ghosts" under ducting conditions. Without the knowledge of anomalous

propagation conditions, it may be thought that decreased ranges are indicative of hardware problems. Without knowledge of the interference patterns, signal fading in UHF communications may also be thought of as indications of hardware problems. A decision aid for the given day will explain such anomalies and, therefore, preclude unnecessary maintenance calls.

Consider the following example. A naval task force is traveling in formation with specified spacing between units. The Officer-of-the-Deck finds he is not able to communicate with the closest ship, yet can communicate with another ship farther away. The first thought may be that the radio receivers of the closest ship are not working correctly. Examining a communication coverage display as illustrated in figure 10-10 reveals, however, surface ducting conditions with its inherent "skip zones." The spacing between the two ships is such that the closest ship is within a skip zone while the farther ship is not. With this knowledge, the ship's spacing may be altered to avoid the skip zones.

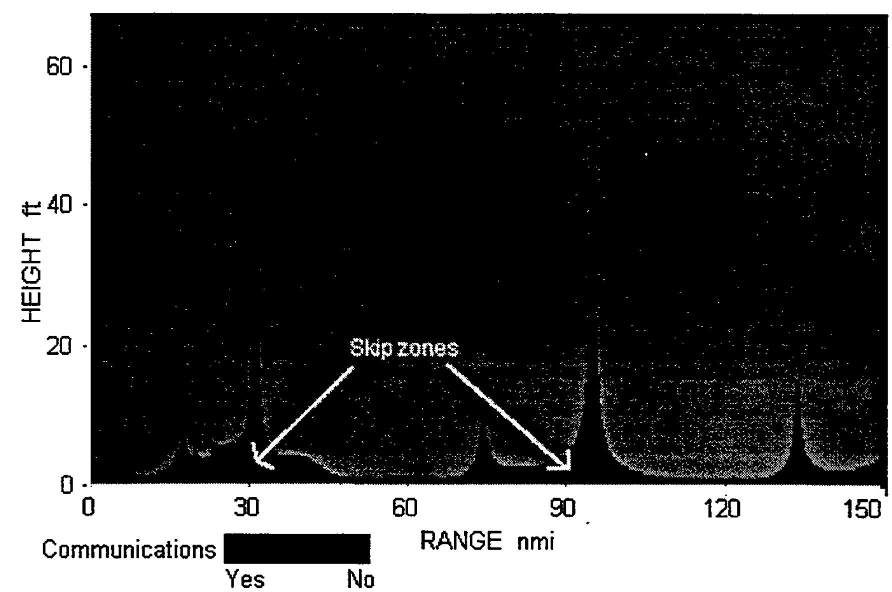


Figure 10-10: Surface-based ducting skip zone conditions.

The same situation may apply to a naval unit approaching a gun or missile range for an exercise. A radio check-in is unsuccessful. It is not uncommon to think that either the radio is not functioning correctly (which leads to a trouble call to the electronics technicians) or one party is not monitoring his receivers (which leads to frustration on the part of both the ship's personnel and the personnel of the range who believe the ship is not following procedures). Examining a communication decision aid may reveal the ship is within a skip zone with respect to the range commander, in which case, the ship can simply move to a location outside of the skip zone. If no skip zone is present, then a trouble call can be made with some assurance that there is an equipment problem.

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13. ABSTRACT *(Maximum 200 words)*

This user's manual documents the Advanced Refractive Effects Prediction System (AREPS) Version 1.0 software program. AREPS computes and displays radar probability of detection, propagation loss, signal-to-noise ratio, electronic support measures (ESM) vulnerability, and UHF/VHF communications capability versus range, height, and bearing from the transmitter. Refractivity data can be entered using several methods, including a fully automatic decoding of common World Meteorological Organization (WMO) codes from Internet homepages of many meteorological organizations. In addition, a 921-station worldwide upper-air climatology database is included within AREPS for assessment using climatological refractivity data. For each bearing, terrain elevation data may be automatically extracted from the National Imagery and Mapping Agency's (NIMA) Digital Terrain Elevation Data (DTED).

The power of AREPS derives not only from its improved propagation model but also from its Windows 95/NT application; it makes full use of drop-down and pop-up menus, object linking and embedding (OLE) features such as file drag and drop and graphics export, and extensive on-line help with graphic examples.

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21a. NAME OF RESPONSIBLE INDIVIDUAL	21b. TELEPHONE *(include Area Code)*	21c. OFFICE SYMBOL
Wayne L. Patterson	(619) 553–1423 e–mail: wayne@spawar.navy.mil	Code D883

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